STEAM BOILERS

AND

BOILER-HOUSE

EQUIPMENT

ŠKODA WORKS LTD.

HEAD OFFICE: PRAGUE

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INTRODUCTION.

The ŠKODA WORKS *(registered as* Limited Company formerly The Škoda Works in Plzeň) *are the most important metal-working undertakings within the borders of the Czechoslovak Republic, and one of the largest steel and engineering works in Europe. In their present form and extent the Škoda Works originated from the well-known Plzeň works (founded by Emil Škoda in the year 1869), to which in the course of time several prominent engineering works were amalgamated, as, for instance, Ringhoffer's engineering works in Prague-Smíchov (founded in the year 1771), Ruston's engineering works in Prague (founded in the year 1832), Bromovský's engineering works in Hradec Králové (founded in the year 1874), as well as a number of other specialized metal-working undertakings, as, for instance, Laurin & Klement's motor car works in Mladá Boleslav, the steel works and rolling mills in Hrádek near Rokycany, the shipbuilding yard in Komárno, the Avia aeroplane works in Prague, and Bartelmus-Donát's electrical engineering works in Brno. From the year 1899 the Škoda Works have been a limited company with a share capital of Kč 200,000,000. The Škoda Works provide employment for up to 39,000 workmen and clerks. In addition to their works and factories (in Plzeň, Doudlevce, Prague-Smíchov, Hradec Králové, Mladá Boleslav, Brno, Hrádek near Rokycany, and Komárno) the Škoda Works have also their own collieries and other mines, as well as extensive lime quarries and lime-kilns. Further they have a financial and business interest in a number of undertakings at home and abroad.*

From the beginning all the engineering works of the present-day Škoda Works (i. e. the engineering works of Škoda, Ruston, Bromovský, and Ringhoffer) participated in the development of steam technics, wherein they obtained a good reputation and considerable success. Through the amalgamation and cooperation of these engineering works, the Škoda Works were enabled to extend and complete their programme in all directions, so that to-day they are in the position to construct and supply complete equipments of machinery for nearly all important branches of industry. The enormous extent of their factories as well as

their manufacturing capacity and the experienced workmen and staff, enable them to utilize all the advantages of specialization in all branches. In the numerous special branches of steam technics all these advantages can be utilized.

The Škoda Works manufacture steam boilers, grates, *as well as* complete equipments for boiler houses *(piping, fittings, reservoirs, pumps, coaling plants, lifting and conveying devices), further* steam engines, steam turbines, *and* electrical machinery, *and are therefore in the position to supply* complete equipments for steam power plants *from their own workshops, whereby the purchaser is offered valuable advantages, not only in projecting, manufacturing, and erecting, but also an undivided and unconditional guarantee for the complete plant.*

This catalogue is devoted to steam boilers and boiler-house equipment. For the other products, which are mentioned above, detailed special catalogues are available.

STEAM BOILER CONSTRUCTION IN THE ŠKODA WORKS.

As mentioned in the introduction, steam boiler construction played an important rôle in the manufacturing programme of all the above-mentioned engineering works, so that their amalgamation united their traditions and all the experience collected in the course of decades.

The success of the Škoda Works in this branch is best proved by the large number of boilers which have been delivered to a number of countries, not only in Europe but also overseas.

The illustrations in this section, which are views of the various works occupied in manufacturing boilers or the material necessary for the boilers, give, if not a complete, at least a general idea of the capacity of the Škoda Works in the sphere of steam boiler construction.

The principal works for manufacturing steam boilers are in Plzeň (Figs. 1, 2, 7, 8, etc.) and Hradec Králové (Figs. 3, 4, 5, 6, etc.).

With the exception of ordinary metallurgical material, such as sheets, tubes, etc., our own special material is used nearly exclusively. For instance, for steam collectors for high-pressure boilers (usually over 40 atm. or 569 lb. per sq. in.) we use forged seamless drums with drawn ends from the large forge in our Plzeň works, which are equipped for making forgings up to an individual weight of 85 tons (Figs. 9 to 13). For the fittings of high-pressure boilers our well-known Plzeň steel works supply the necessary castings and also electro steel. Special castings for low-pressure fittings and economizers, as well as fire-proof castings for grates, are manufactured in our extensive foundries in Plzeň and Hradec Králové. In order to study the properties of the manufactured material as well as the technological processes in its manufacture, and also to control all changes that take place in the course of working up, we have a RESEARCH INSTITUTE provided with the most perfect and up-to-date equipment for mechanical, microscopic, chemical, and calorific tests and examinations.

Many years of cooperation between the steel works and the research institute have provided the construction department with means of inestimable value—such as is rarely met with in any works—which are made full use of in modern high-pressure technics, where the question of material plays the principal rôle.

In the same way the workshops, in which the material is worked up, are equally carefully equipped. Hereby the most approved working methods and the most up-to-date working machines are employed. All the holes in the boiler shell are drilled, and the caulking edges planed or machined. For higher steam pressures the bottoms are specially adapted by machining, the seamless forged drums for the highest pressures are machined precisely both inside and outside. Riveting is done without exception by machinery, hydraulically (as far as practicable), at the same time carefully checking the final pressure on the rivet, thus excluding from the very beginning any unfavourable influence or any damaging of the riveted plates.

The valves are made in our own fittings workshops in Plzeň, which, in the same way as all our other mechanical workshops, has the underlying principle that the individual parts must be interchangeable, and high-precision machine tools, tools, and tolerence gauges used for machining. The tools and also the measuring tools are made in our own tool factory, which employs 800 workmen.

As a result of these working methods, utilizing the latest progress in tool technics, the Škoda Works are enabled—even when competition is most severe—to construct the boilers in the workshops most carefully, to guarantee their absolute reliability and safety in service, and to justify the full confidence of our clients.

The Škoda Works spare no pains and expense, not only in the perfect equipment of their shops and the selection of the working methods, but also in respect of the constructive solution of the individual types of boilers, in order to make their products always the last word in progress. By means of intensive work in design and research, and on the basis of extensive experience in service, all our types of boilers have developed to such a high degree of technical perfection in the course of decades, that they all satisfy even the most severe conditions as to

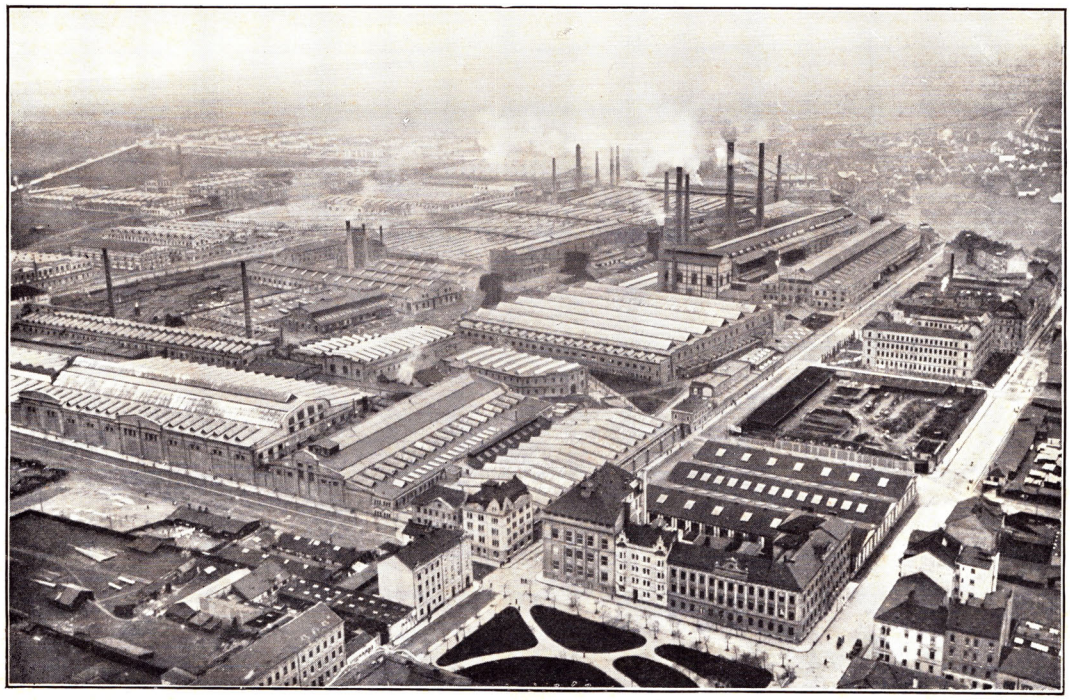


Fig. 1. Plzeň Works.

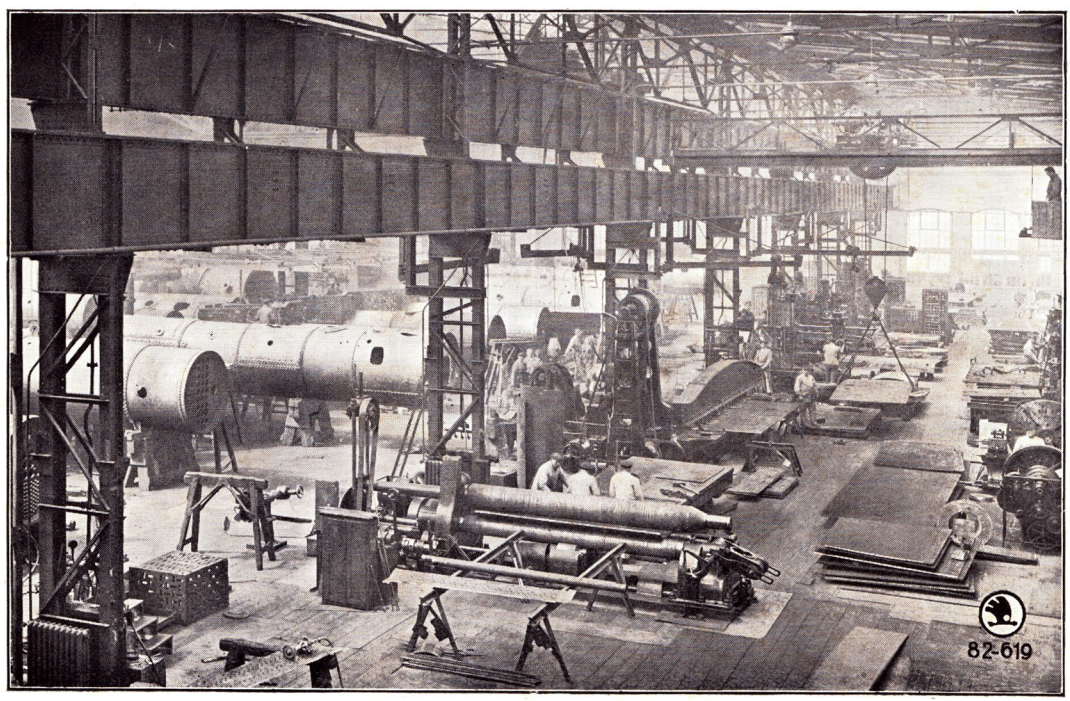


Fig. 2. Boiler Shop in Plzeň.

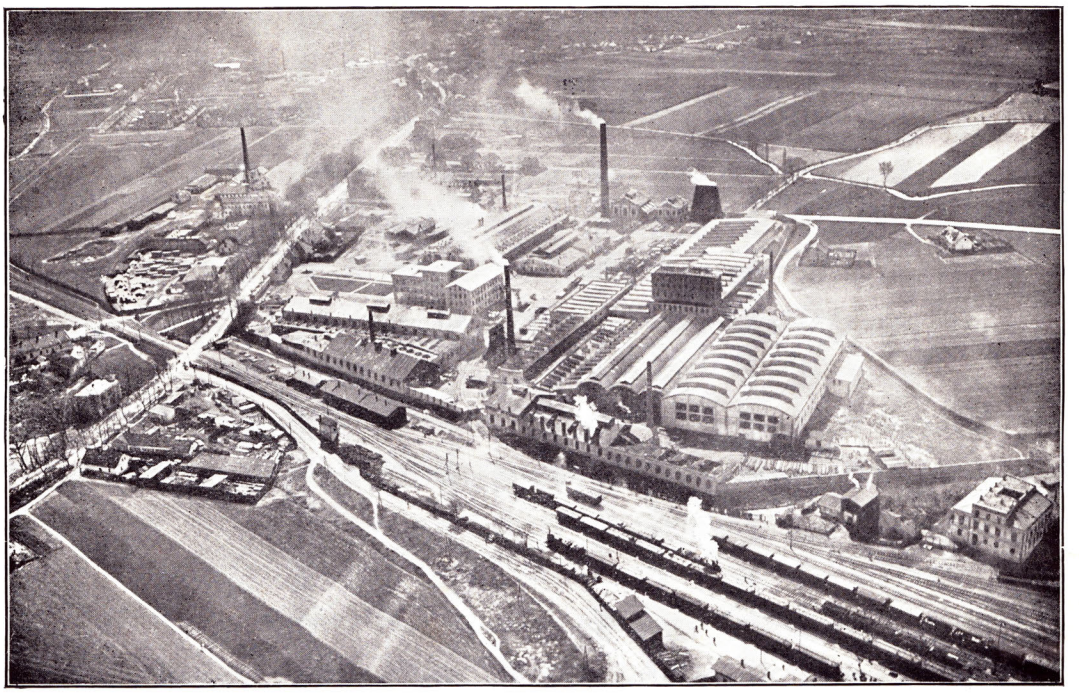


Fig. 3. Engineering Works in Hradec Králové.

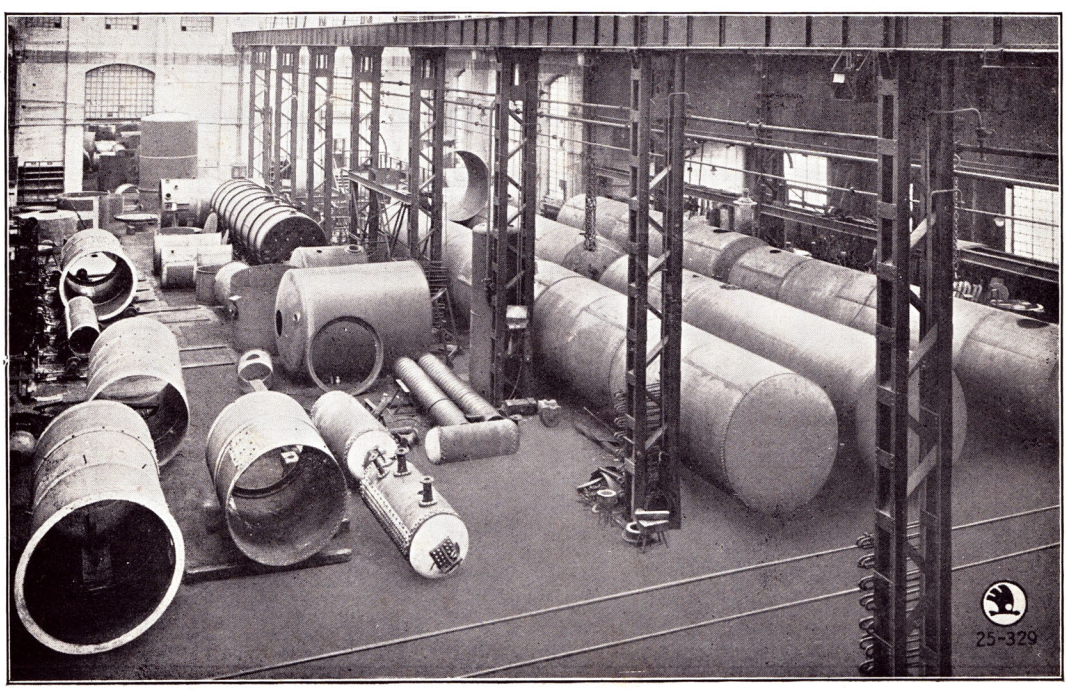


Fig. 4. Boiler Shop in Hradec Králové.

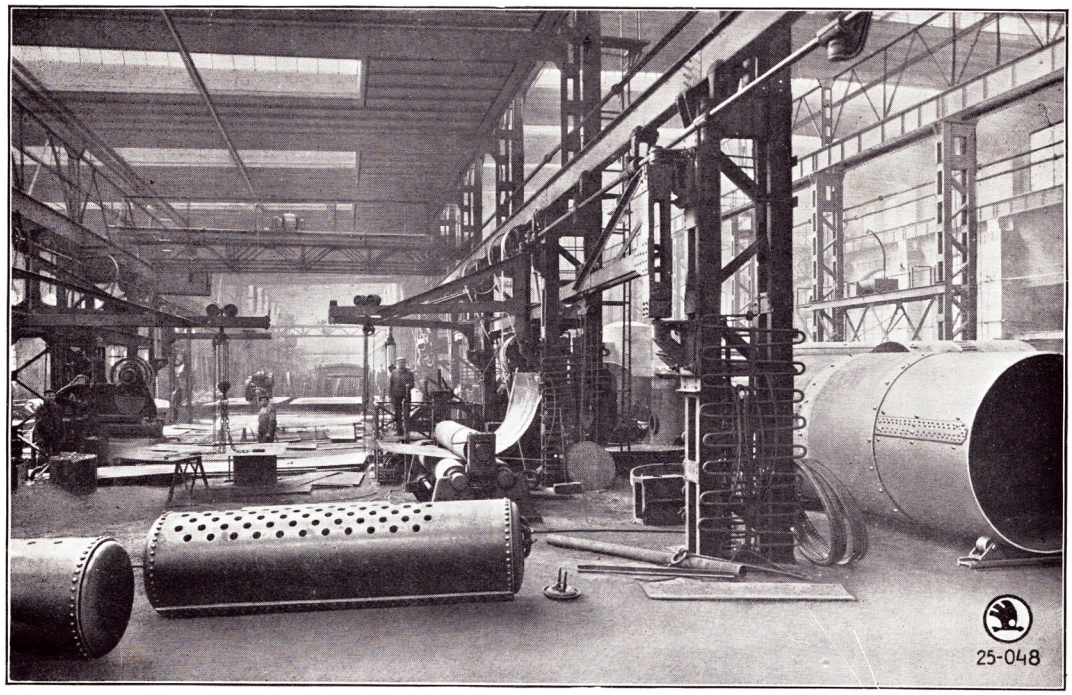


Fig. 5. Department for Plate Working in the Boiler Shop in Hradec Králové.

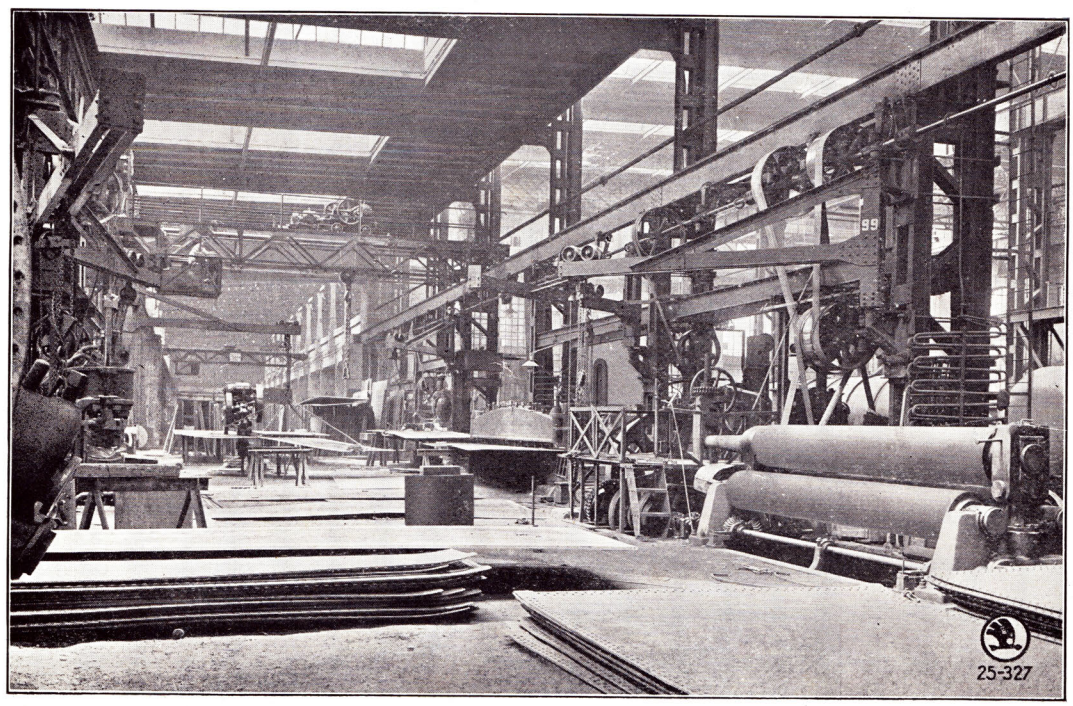


Fig. 6. Plate Bending and Planing Machines in the Boiler Shop in Hradec Králové.

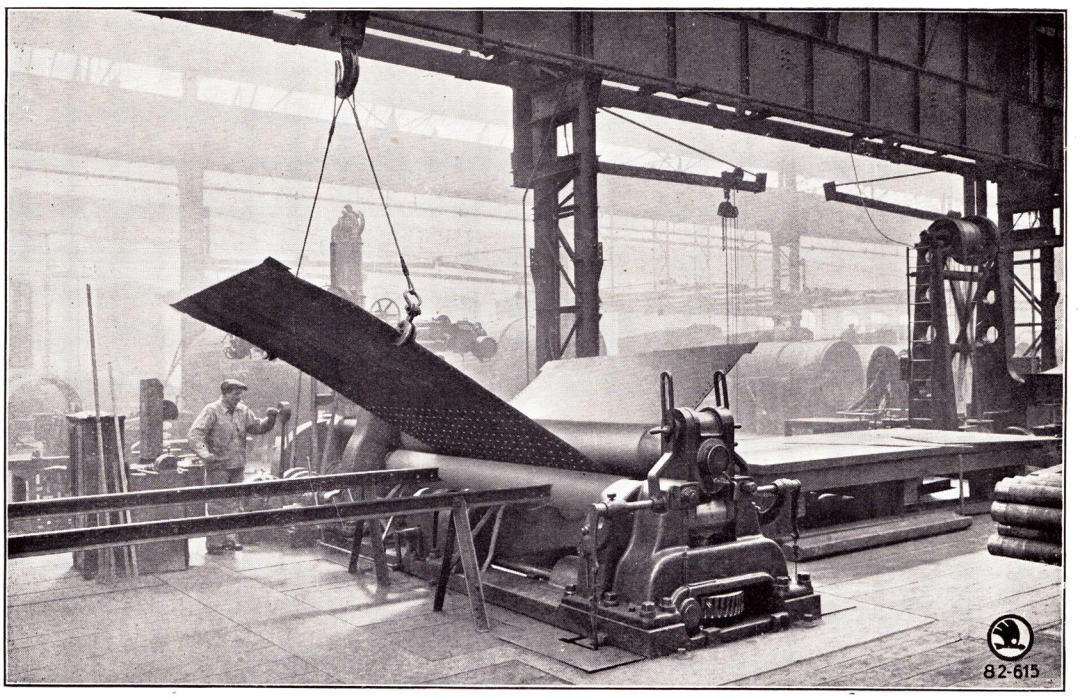


Fig. 7.
Plate Bending Rolls in the Plzeň Boiler Shop.

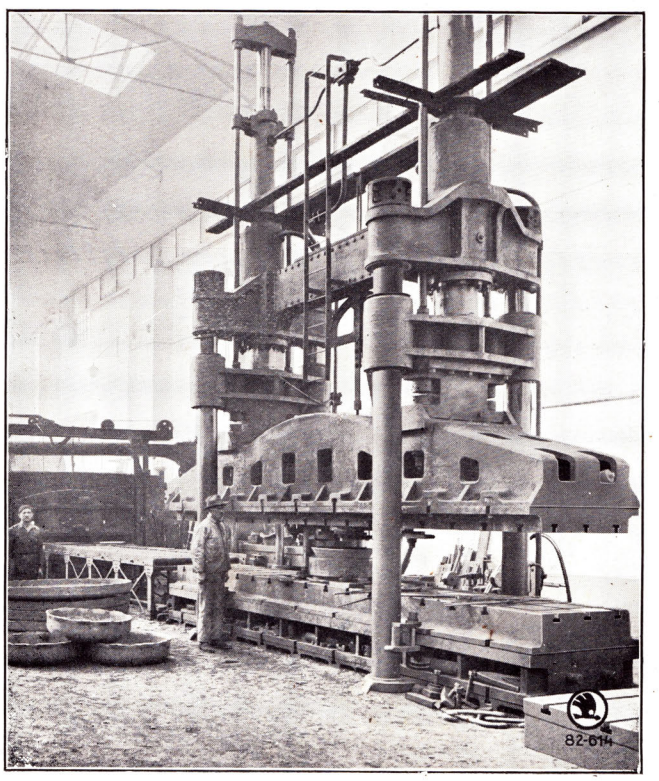


Fig. 8.
Hydraulic Press in the Plzeň Boiler Shop.

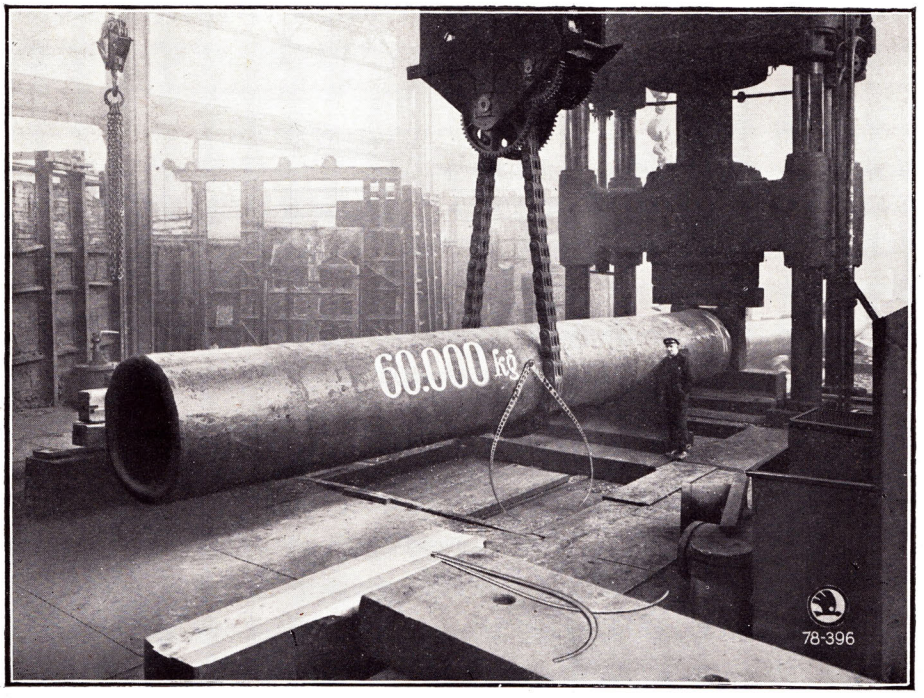


Fig. 9. Forged High-Pressure Drum.

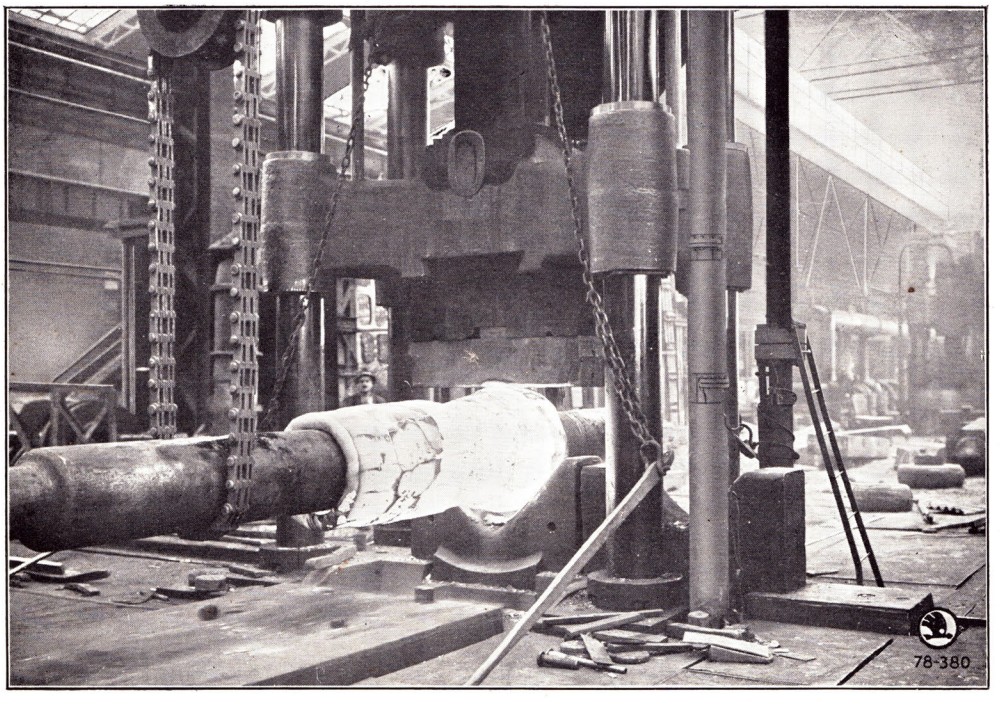
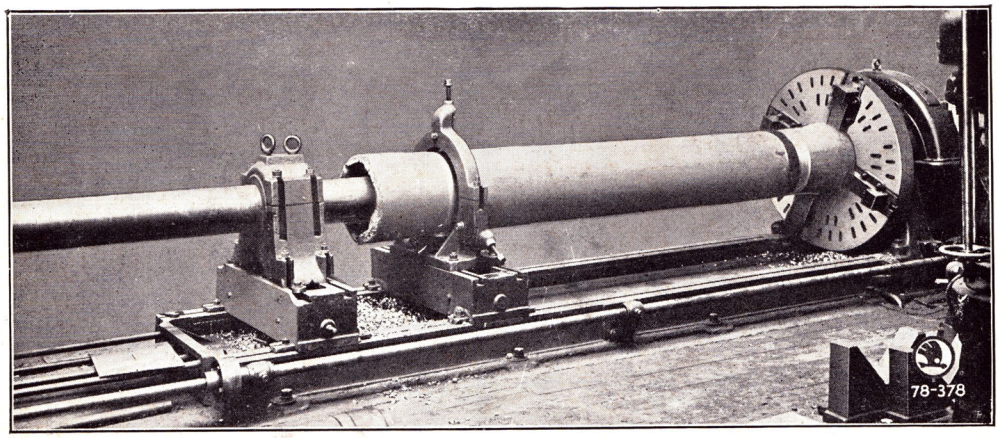
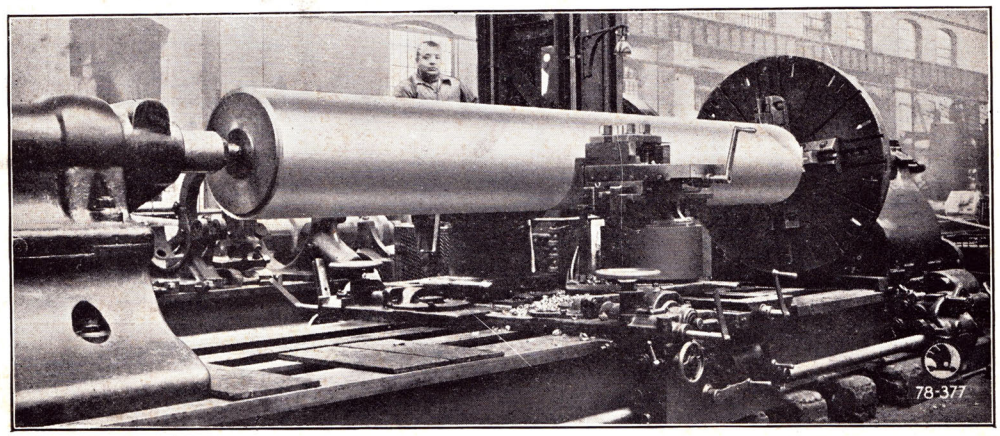
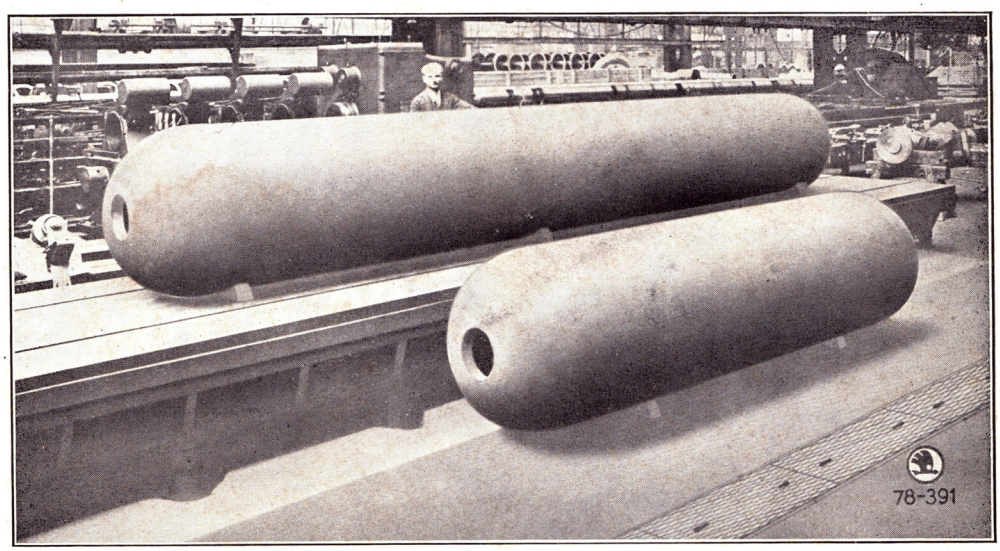


Fig. 10. Forging a High-Pressure Drum.







Figs. 11, 12, and 13. High-Pressure Boiler Drums in Course of Manufacture and after Completion.

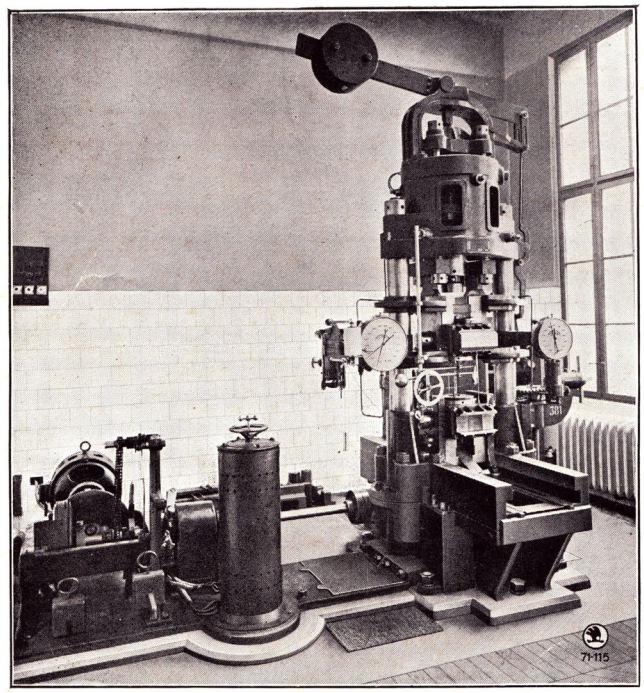


Fig. 18. Machine for Testing Tensile Strength in the Research Institute in Plzeň.

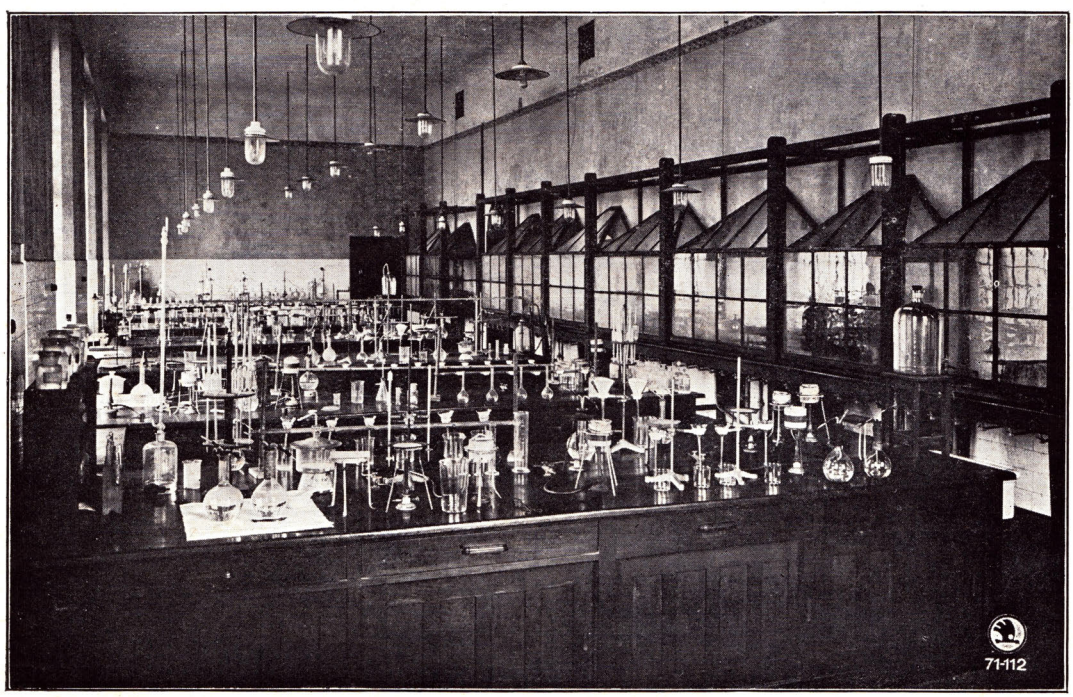


Fig. 19. Analytical Laboratory in the Research Institute in Plzeň.

safety and reliability in service, best utilization of fuel, easy accessibility of all parts for cleaning and replacing, etc.

It is quite obvious that the workshops of the Škoda Works, being equipped with the most perfect and up-to-date machines, are able to keep pace with the rapid development in steam boiler construction. The Škoda Works now deliver boilers units of any output required (up to 150 tons per hour) and of a working pressure up to 70 atm. (1000 lb. per sq. in.) and more.

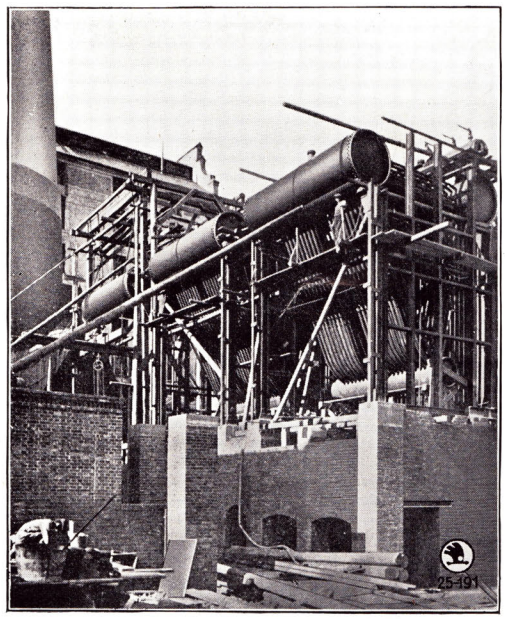
The wide range of types constructed by us, together with the vaste experience which we have gained in the course of time in most diverse circumstances and the most difficult working conditions, form a sufficient guarantee for our clients that in each case we choose the most suitable type of boiler, and also accommodate the other parts of the plant to the special requirements.

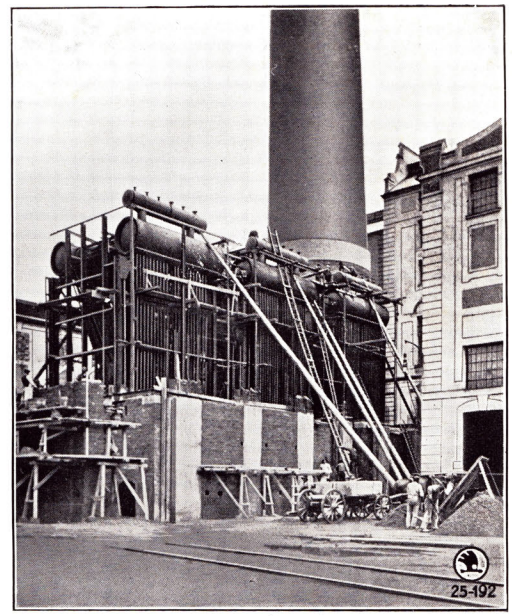
For analyzing fuel, feed water, etc., we have our own laboratories. The equipment of our own power plants, in which the total output is over 50,000 h. p., gives us the possibility to carry out evaporation tests with all kinds of fuel on all the types of grates manufactured by us, and also to test all kinds of working equipment, measuring, and regulating apparatus, so that our clients can have the certainty that only what is most suitable will be recommended and delivered. In addition to this the cooperation of the boiler engineering department with our other general and special departments occupied with steam technics, is a guarantee that the boiler plants projected by us can most favourably be inserted into the works as a whole with regard to flow of material and energy.

The following chapters give details of the design of our individual types of boilers and their accessories.

STEEP-TUBE BOILERS.

Steep-tube boilers are characterized by specially good water circulation and great elasticity to allow heat expansion of all parts, admit the highest specific evaporative capacity of the heating surface, whereby a high output on a small floor space can be attained. Adaptation to up-to-date, wide mechanical grates and pulverized-coal firing can easily be carried out. They are very suitable for





Figs. 20 and 21. Group of Steep-Tube Boilers in Course of Erection.

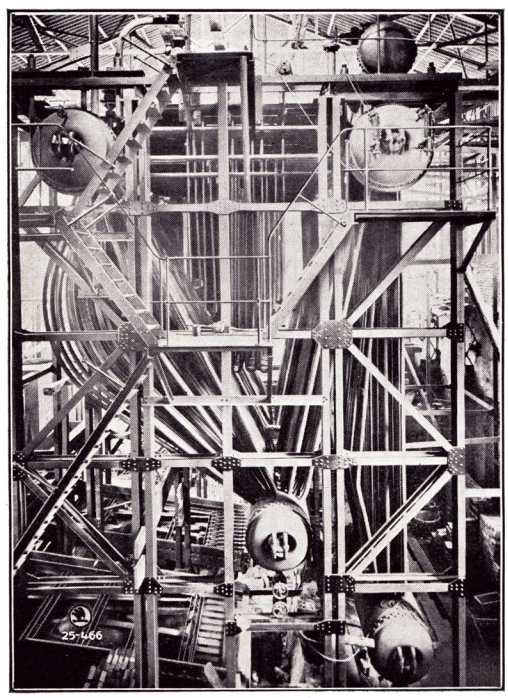


Fig. 22. Erection of a Steep-Tube Boiler with Four Drums.

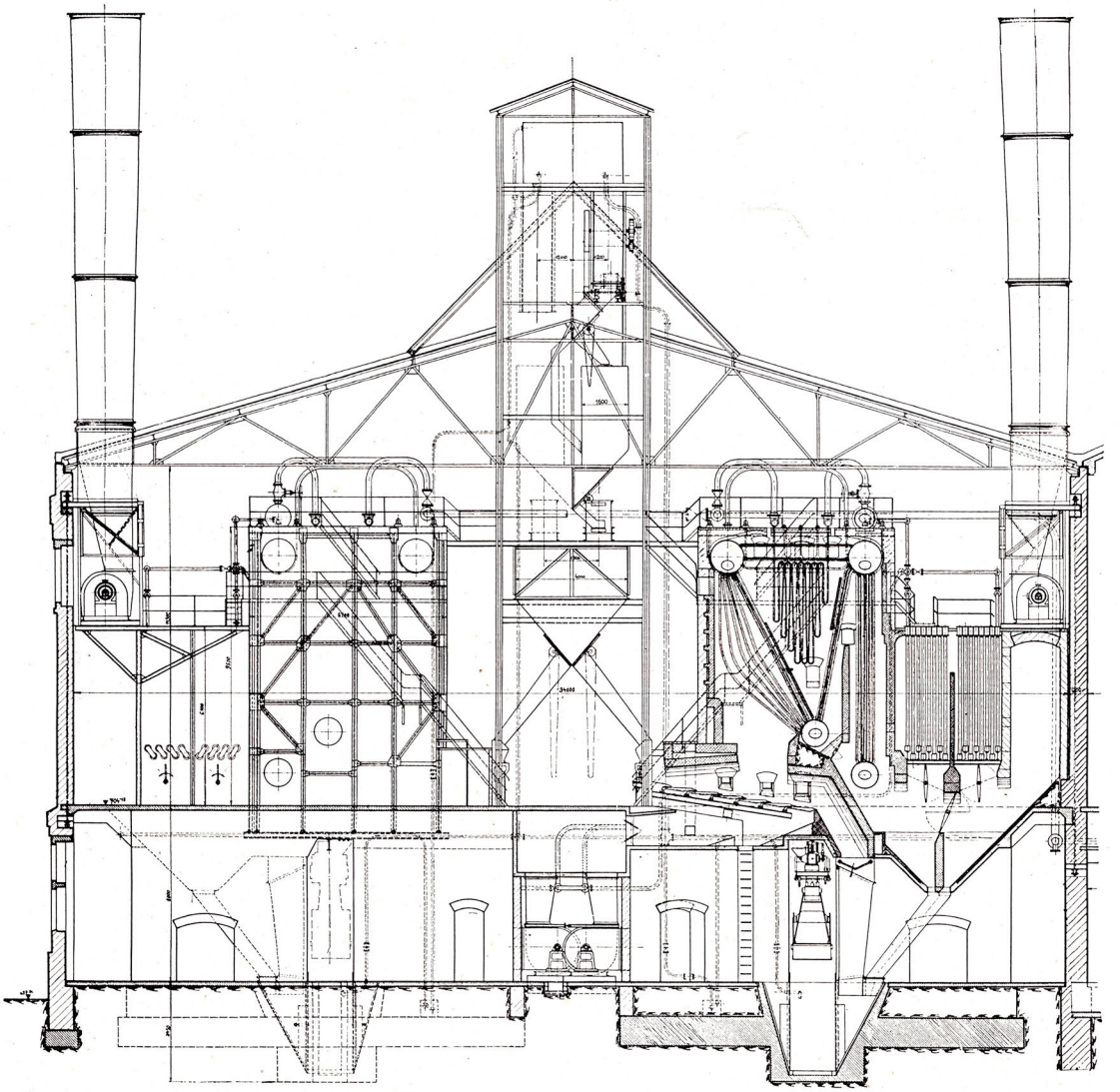


Fig. 23. Section through a Boiler House with Steep-Tube Boilers with Four Drums and Economizers with alternate Short and Long Registers. Lomshakoff Stoker.

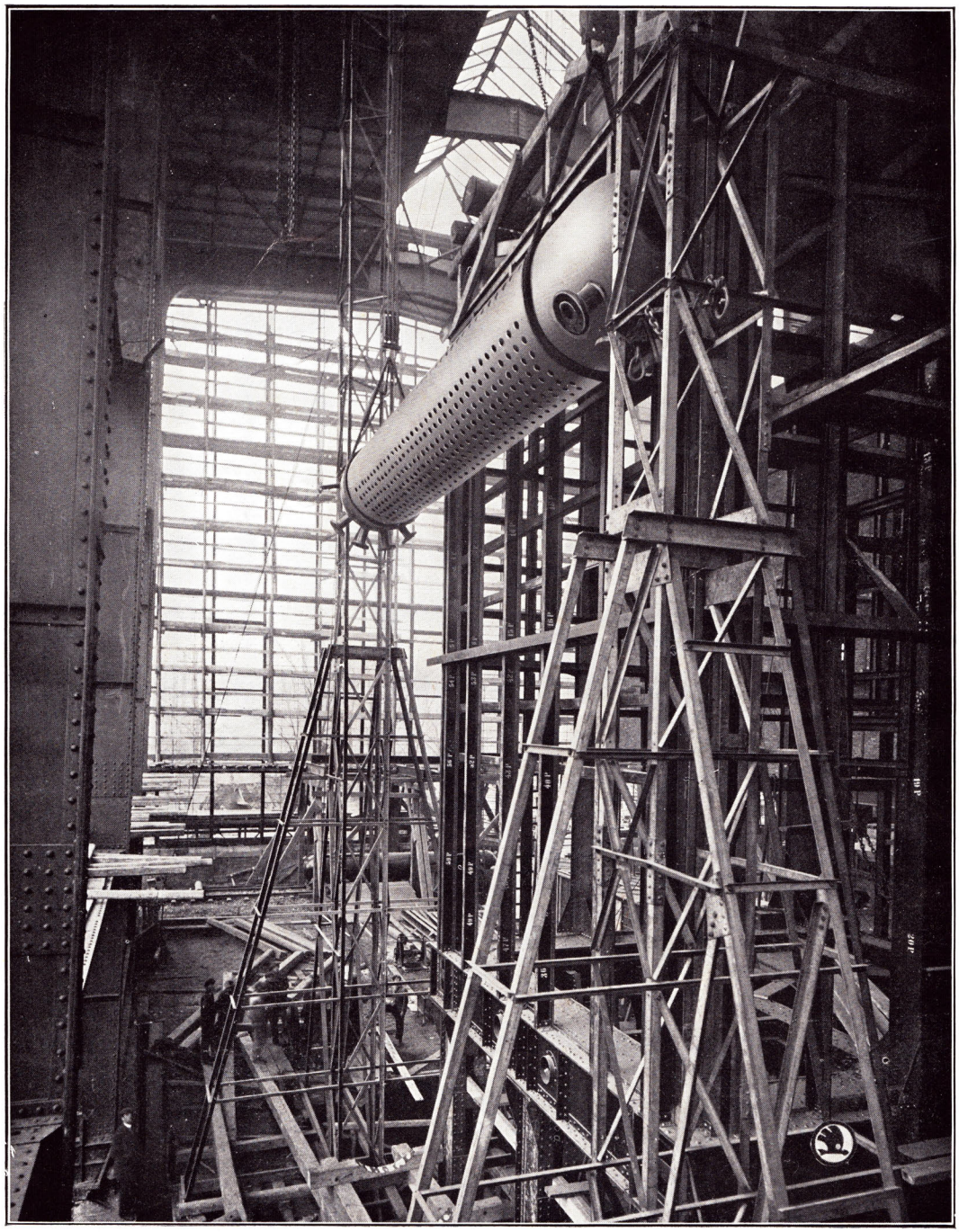


Fig. 24. Erection of a Boiler in a High-Pressure Plant.

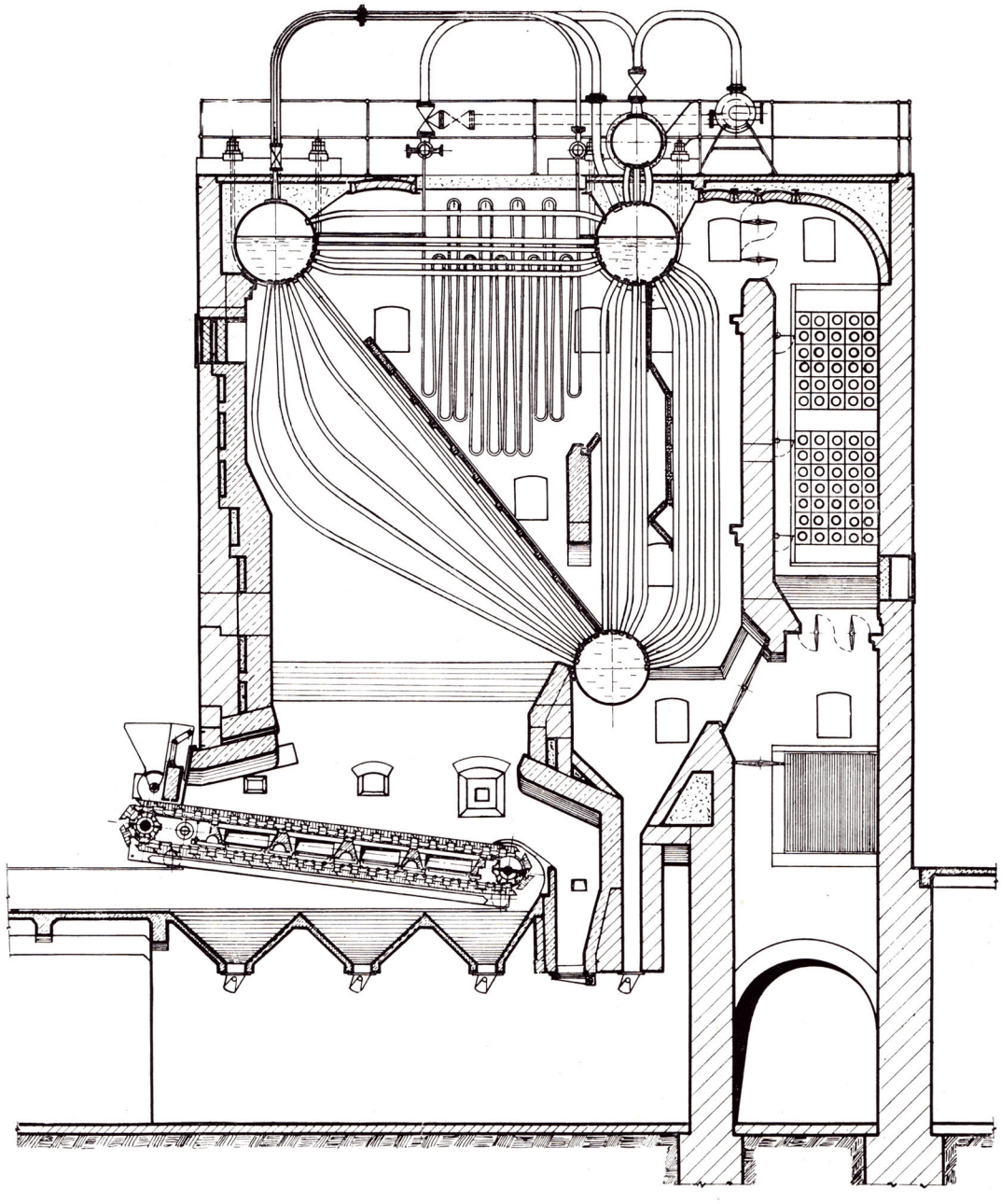


Fig. 25. Steep-Tube Boiler with Three Drums, Ribbed-Tube Economizer, Air Preheater, and Forced-Draught Chain Grate.

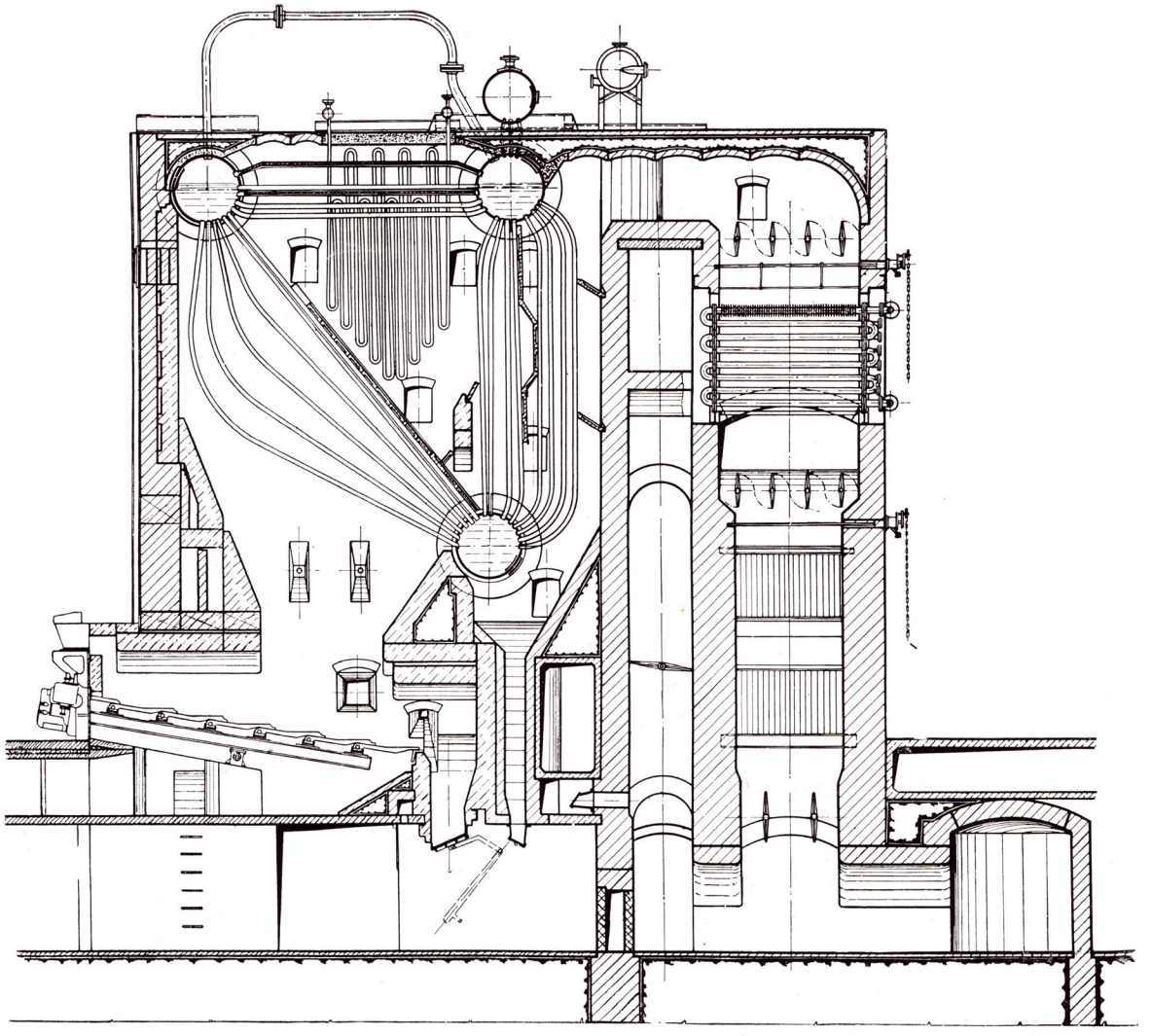


Fig. 26. Steep-Tube Boiler equipped with Ribbed-Tube Economizer, Air Preheater, and Lomshakoff Overfeed Stoker.

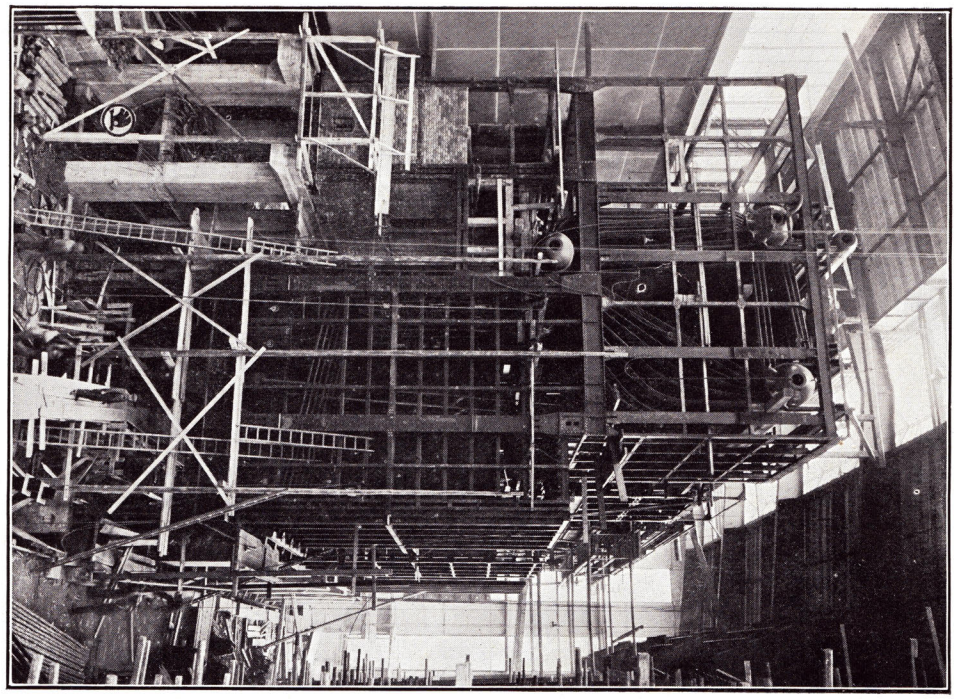


Fig. 27. Erection of a High-Pressure Boiler Plant with Pulverized-Coal Firing for a District Heating Station.

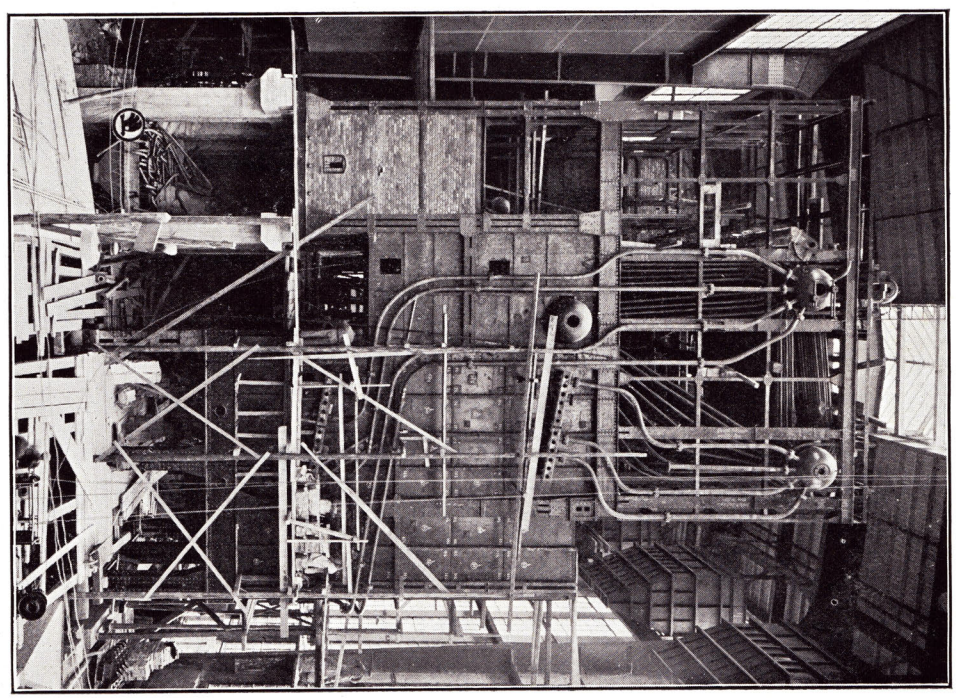


Fig. 28. Erection of a High-Pressure Boiler Plant with Pulverized-Coal Firing for a District Heating Station.

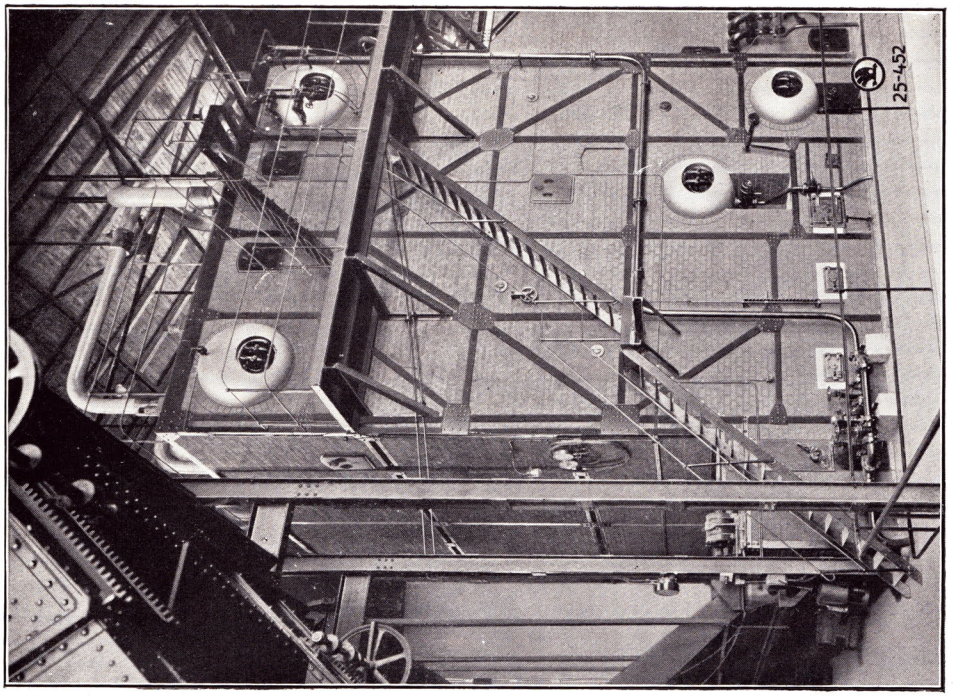


Fig. 29. Interior of a Boiler House with High-Pressure, Stoker-fired Boilers.

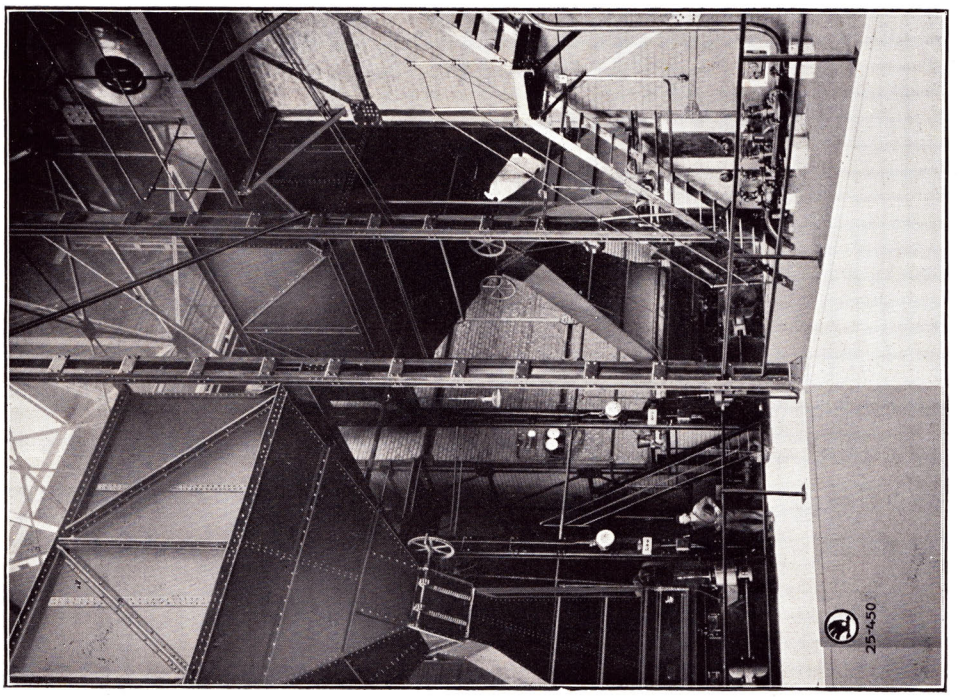


Fig. 30. Interior of a Boiler House with High-Pressure, Stoker-fired Boilers.

higher steam pressures. On account of these properties steep-tube boilers soon became widely used, especially for larger units in all branches of industry, principally, however, in electric power stations.

We manufacture steep-tube boilers in sizes from 200 m² (2153 sq. ft.) heating surface up, and for all usual steam pressures. They consist of several nests of boiler tubes, which are expanded into 3 or 4 drums. Straight seamless tubes (Mannesmann tubes) are used up to 22 atm. (313 lb. per sq. in.) steam pressure with an external diameter of 95 *mm.* (3¾ ins.), so that they can easily be cleaned and overhauled. For higher steam pressures bent tubes with an external diameter of 76 *mm.* (3 in.) are used, but these require pure boiler feed water. For high-duty boilers, however, in order to obtain better heat expansion, the tubes are bent. The upper drums have a larger diameter (normally 1100—1600 *mm.* or 43¼—63 ins. according to the pressure) to facilitate liberation of steam. Up to 40 atm. (569 lb. per sq. in.) they are riveted, above 40 atm. they are fully forged, are provided with drawn round ends, and are machined on both surfaces. The feed water is led to the rear upper drum by means of a special trough. In the steam space, in which the air is separated, the feed water (in the case of the four-tube nest type) flows first through the rear hanging economizer tube nest, the lower drum of which serves as mud collector, and then circulates in a triangle through the three front tube nests. The steam, which is generated principally in the front tube nest, is separated in the front upper drum, from which it is led through connecting tubes to the rear upper drum, and is drained through a perforated tube. In the case of high-duty boilers, there is usually another steam collector arranged over the rear upper drum. The superheater is arranged behind the front tube nest, either horizontal or suspended. The boiler setting in the framework is so designed as to assure absolute freedom for heat expansion. The rear upper drum is fixed, the front upper drum rests on rolls or is suspended, having freedom of movement horizontally. The lower drums hang freely on the tube nests. In the case of heavily stressed boilers, as already mentioned, the tubes of the first nest are bent so that they can expand freely.

Fig. 31. Interior of a Boiler House with High-Pressure, Steep-Tube Boilers (36 atm. or 512 lb. per sq. in) of 600 m² (6458 sq. ft.) Heating Surface each, with Pulverized-Coal Equipment.

INCLINED-TUBE BOILERS.

Boilers with inclined tubes also have good water circulation and a high output. Their total height is less than for steep-tube boilers. Therefore they are more advantageous for smaller units, for which the proportion between the height and the small width of steep-tube boilers would be unfavourable.

These boilers are usually designed in sizes from 80 to 300 m² (861 to 3230 sq. ft.) heating surface and for steam pressures up to 22 atm. (313 lb. per sq. in.). The heating surface is formed by means of a nest of straight tubes of 95 *mm.* (3¾ in.) outside dia., which is placed at an angle of about 15° to the horizontal, and have their ends beaded into the rectangular riveted chambers. The front header is riveted directly onto the upper boiler drum, the rear header onto the mud collector, which is connected with the upper drum by means of a wide circulation tube. This arrangement offers the following advantages:

1. The large connecting sections result in good circulation and therefore facilitate separation of the steam.

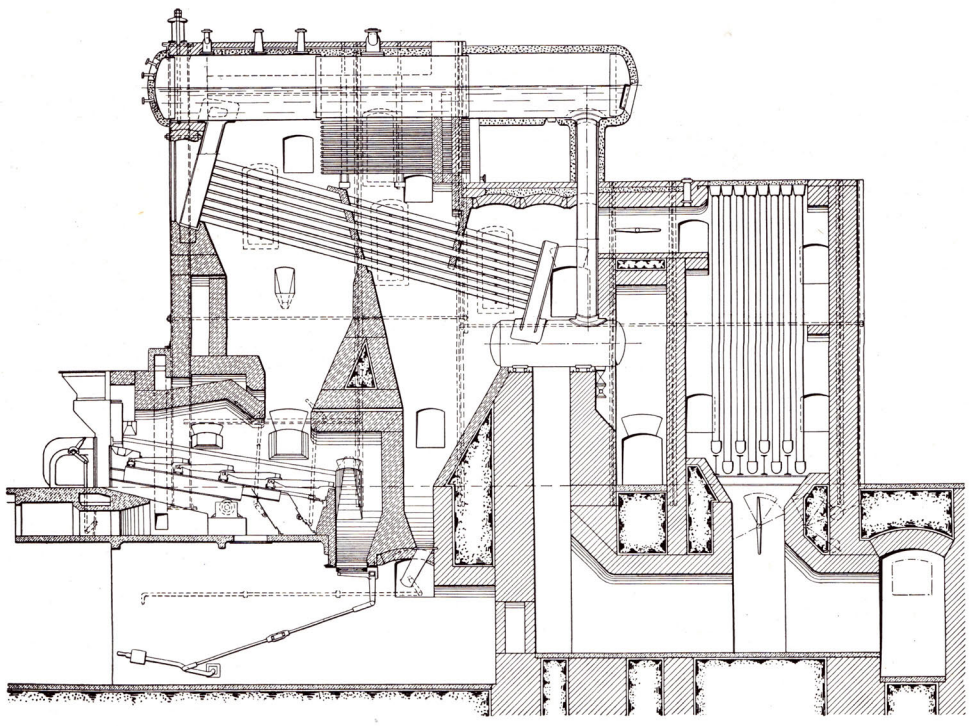


Fig. 32. Section of an Inclined-Tube Boiler with Horizontal Superheater and Economizer with alternate Short and Long Registers. Lomshakoff Mechanical Stoker.

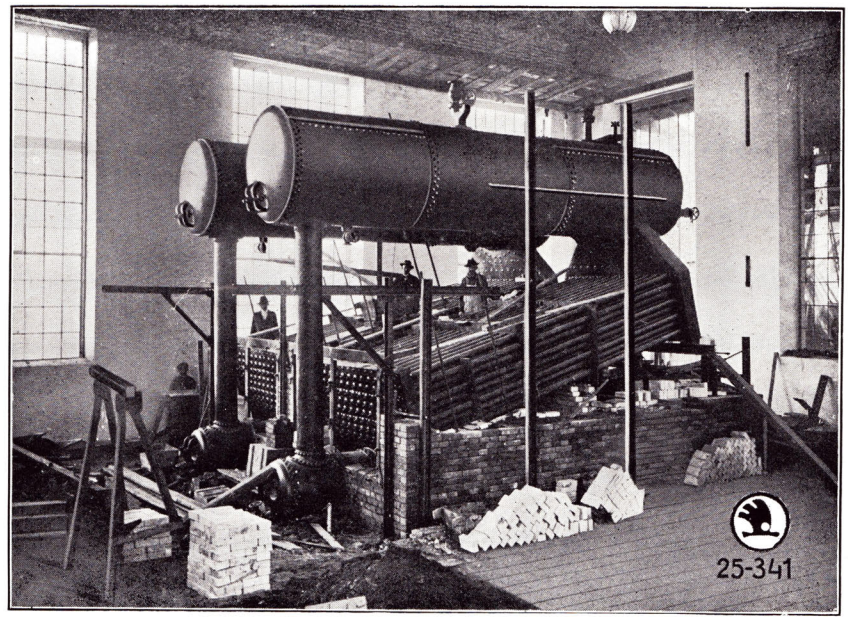


Fig. 33. Two Inclined-Tube Boilers in Course of Erection.

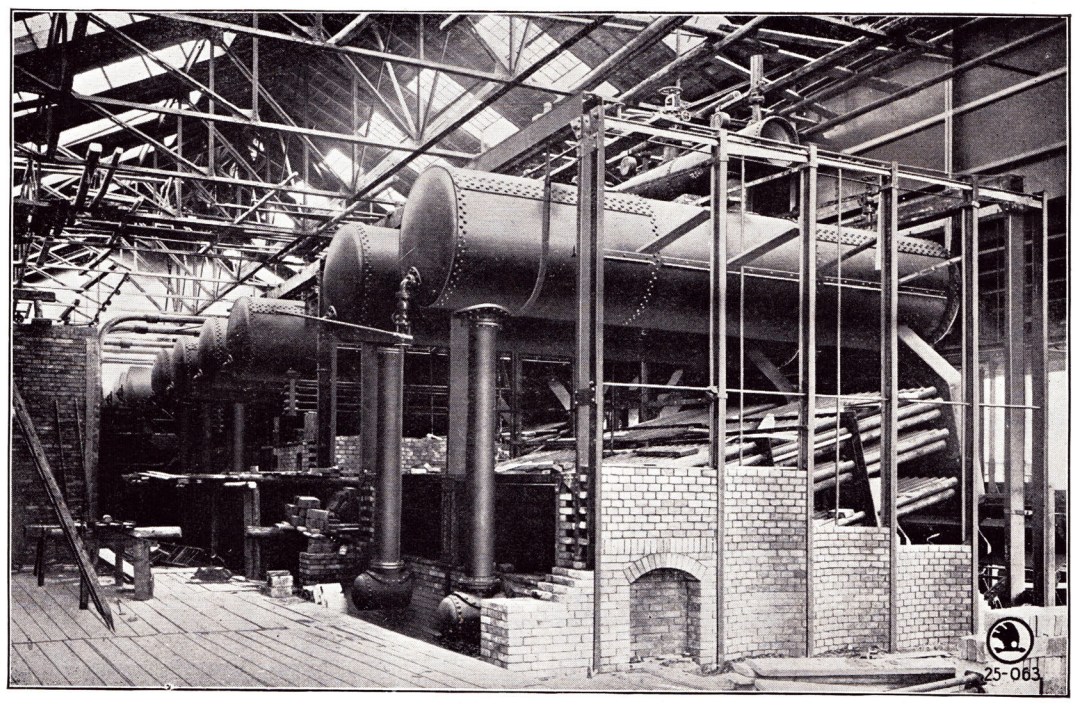


Fig. 34. Group of Inclined-Tube Boilers in Course of Erection.

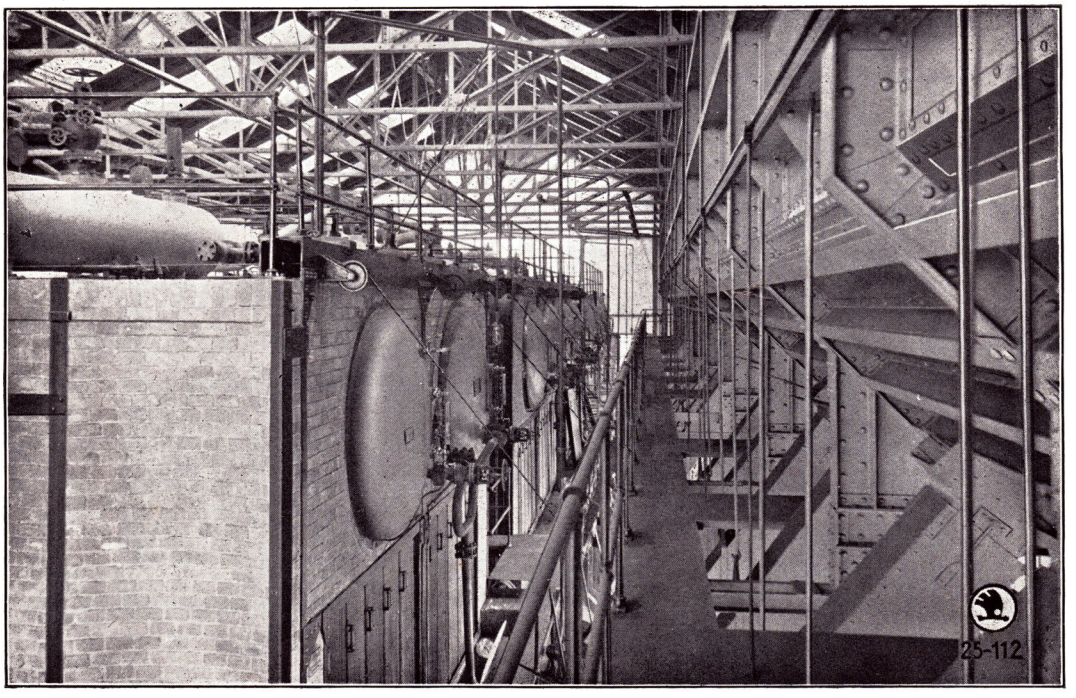


Fig. 35. Interior of a Boiler House with Inclined-Tube Boilers each with 300 m² (3230 sq. ft.) Heating Surface.

2. The feed water is admitted from underneath to the rear inclined chamber, so that the water comes first to the lower tubes, in which the greatest part of the steam is generated.

3. The mud collector underneath the rear chamber prevents any mud entering the tubes, and therefore prevents the tubes being burnt through.

4. The tubes are cleaned and replaced by means of joints in both headers. Feeding takes place in the upper boiler. The superheater is under the upper boiler drum, and is arranged between the first and second flue in such a way that its collecting pipes lie outside the boiler setting.

FLUE BOILERS AND COMBINED MULTITUBULAR BOILERS.

In addition to the above-mentioned boilers, older boiler types with large water capacity are still in comparatively frequent use, as they are cheaper than

water-tube boilers when needed for small steam outputs (with only a few m^2 heating surface) and for low steam pressures. The large water capacity also serves as an accumulator, and is therefore specially suited for works with irregular steam consumption. For large-water-space boilers working at lower pressures, feed water of rather unsuitable properties may be used.

Both flue boilers and combined multitubular boilers are specially suitable for small outputs and normal circumstances (unskilled boiler attendants, hard feed water, etc.), and also when a large accumulating capacity is required in the boiler itself.

We manufacture the above boilers normally up to 14 atm. (200 lb. per sq. in.) steam pressure, and up to an output of approx. 3000 kg. (6600 lb.) of steam per hour. According to the output they are constructed either as vertical boilers with fire tubes, or as horizontal with one or two flue tubes (Cornwall), or as combined boilers (Tischbein, Meunier, and others).

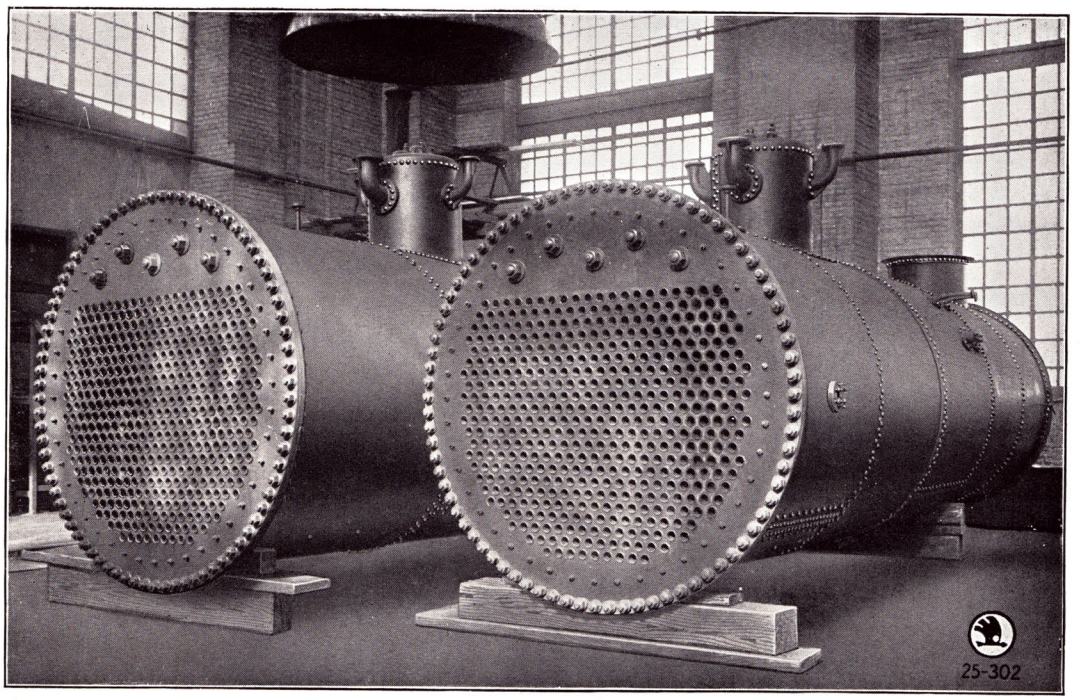


Fig. 36. Two Waste-Heat Boilers each with 424 m² (4564 sq. ft.) Heating Surface.

WASTE-HEAT BOILERS.

According to circumstances we build waste-heat boilers (in which the waste gases from internal combustion engines, gas producers, industrial furnaces, etc. are utilized) either as boilers with fire tubes, which can be taken out to clean the boiler (for small quantities of gas which does not contain too much dust, e. g. exhaust gases from internal combustion engines), or as water-tube boilers with a hanging nest of seamless tubes which are beaded into the boiler drums (for larger quantities of gas and for waste gases containing much dust).

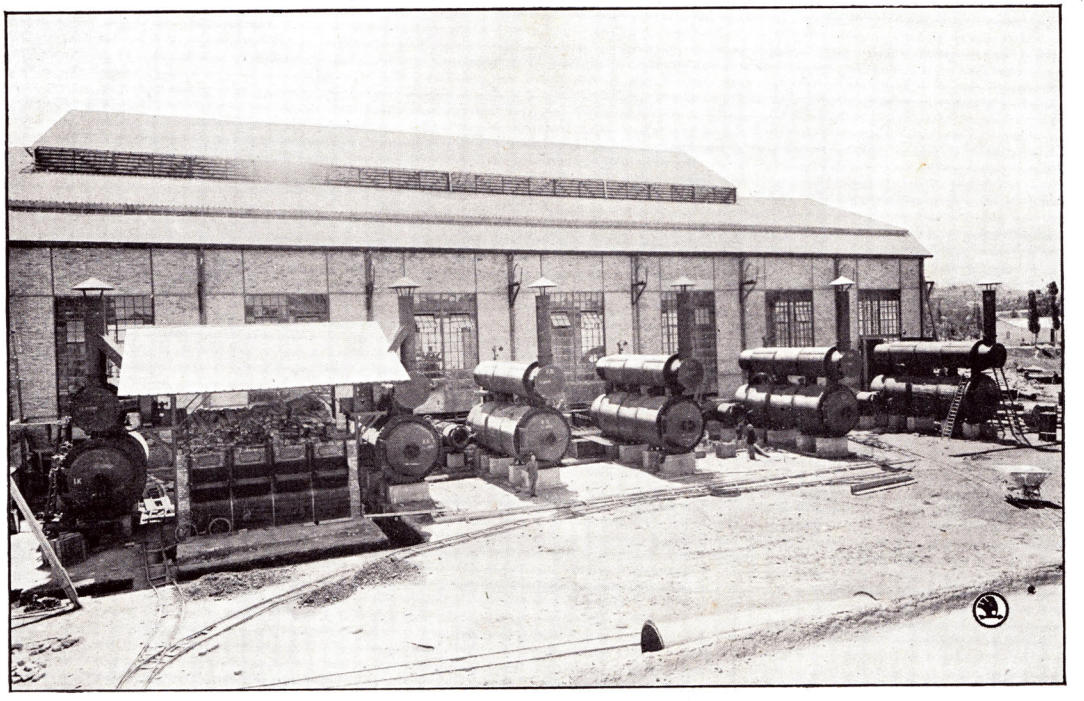


Fig. 37. Group of Waste-Heat Boilers during Erection.

MARINE AND SPECIAL BOILERS.

As a rule we build marine boilers with flue tubes and return smoke tubes over them up to 14 atm. (200 lb. per sq. in.) steam pressure. Among special boilers we manufacture principally locomotive boilers of all sizes, also boilers for steam road rollers and steam ploughs, and special vertical boilers for our *"Škoda-Sentinel"* steam lorries.

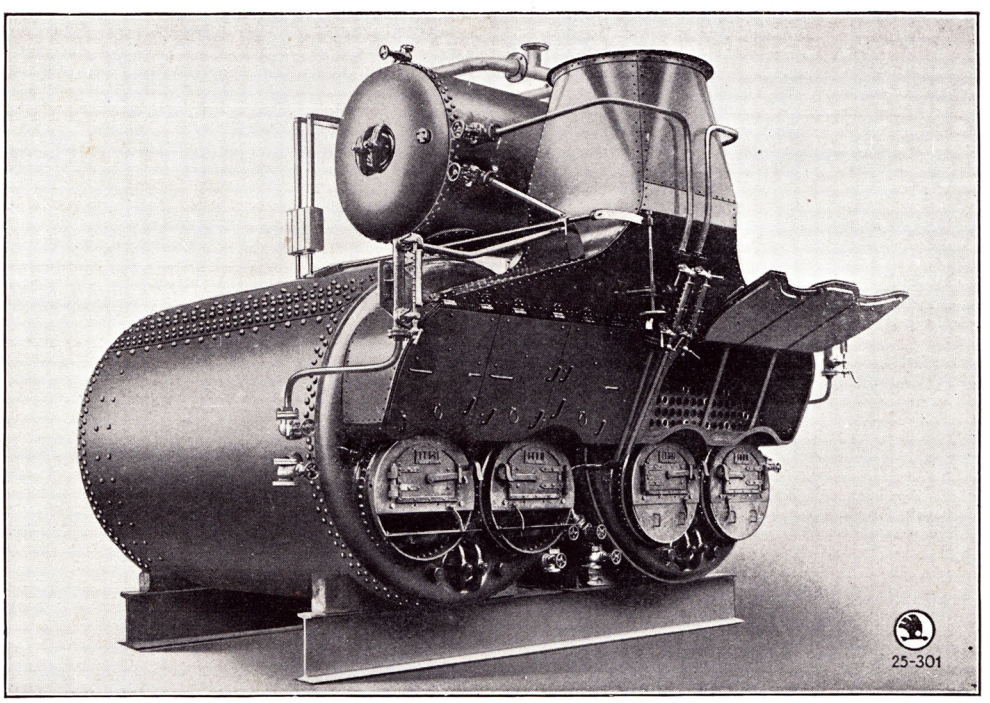


Fig. 38. Marine Boilers with 100 m² (1076 sq. ft.) Heating Surface.

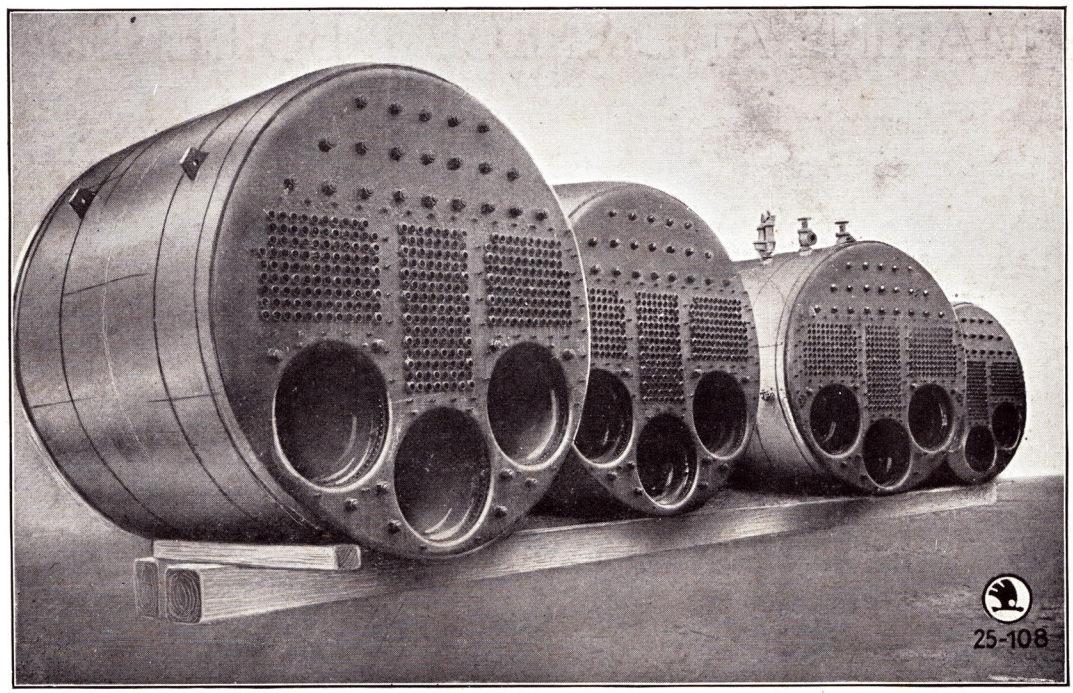


Fig. 39. Group of Marine Boilers for Ocean Steamers each with 250 m² (2691 sq. ft.) Heating Surface.

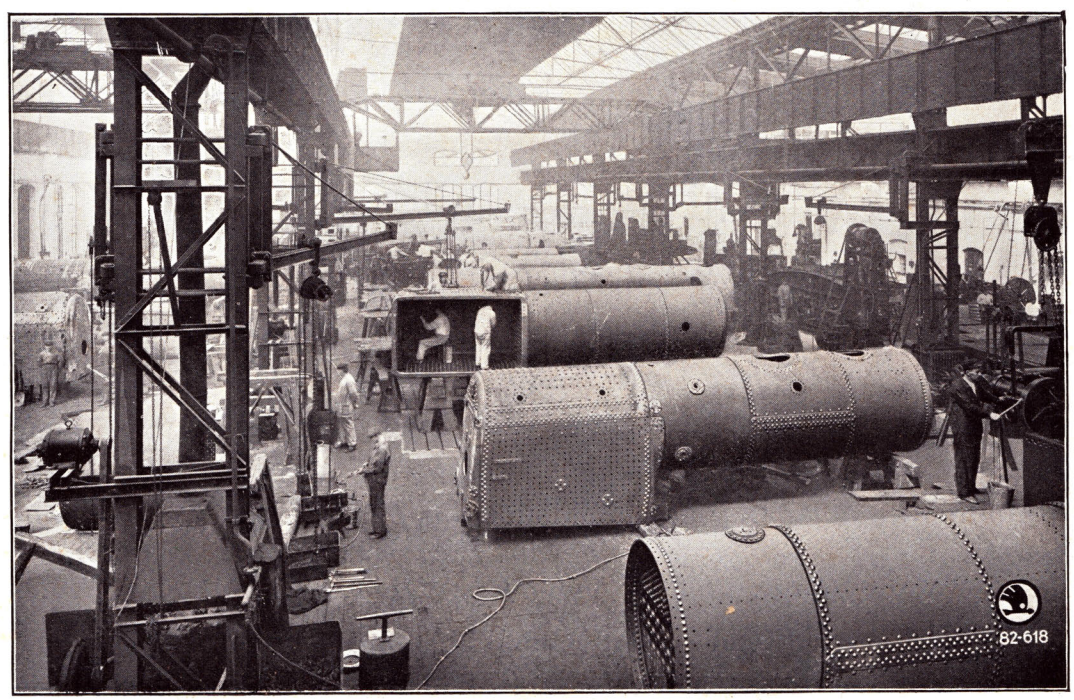


Fig. 40. View of the Locomotive Boiler Shops in Plzeň.

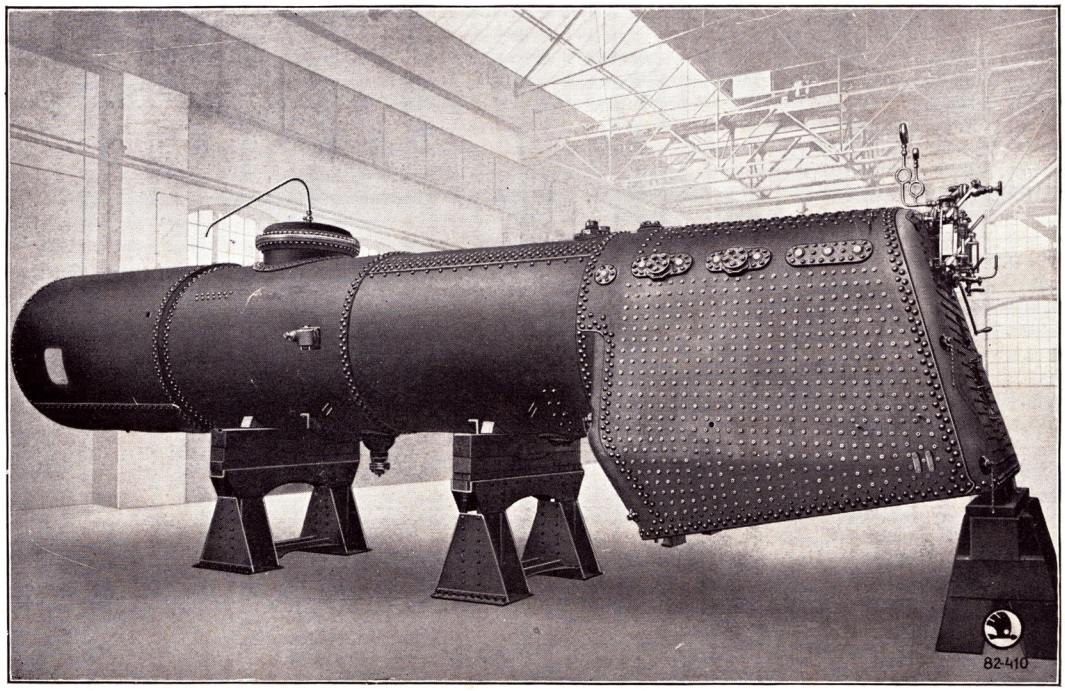


Fig. 41. Locomotive Boiler for a Three-Cylinder Express Train Locomotive.

STEAM SUPERHEATER AND STEAM TEMPERATURE REGULATION.

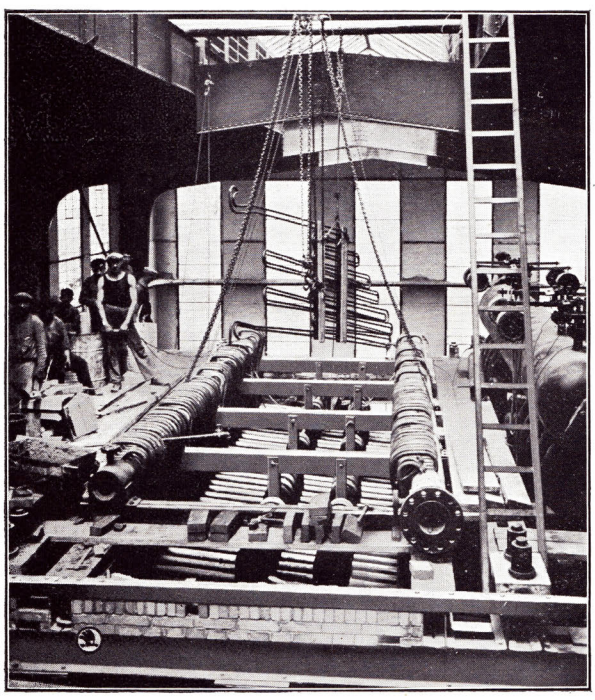
The superheaters consist of seamless coil tubes, the ends of which are expanded into seamless headers. For low steam pressures these headers are square, for higher pressures they are round. The openings for beading are closed by means of expanded-in plugs. The headers are always outside the boiler setting. The superheater coils are arranged either horizontal or suspended according to the type of boiler and local service conditions. On firing up the boiler the superheater can be filled with water from the upper boiler by means of a connecting tube, thus safeguarding the boiler against burning, or cooled by steam passing the superheater.

If the plant is designed only for medium superheating a simple regulating flap is sufficient for governing the steam temperature, this flap regulating the

inlet of flue gas to the superheater. However for higher temperatures (375° to 450° C. or 707° to 842° *F.)* the temperature of the superheated steam must be exactly regulated. In such cases we use Peča's patent steam temperature regulator, which at the same time safeguards the superheater from too high temperatures. The scheme of such a regulator is given in Fig. 46.

The main organ of Peča's regulator is a nest of tubes which, according to local circumstances, is built either on the boiler in a cast-iron or cast-steel shell, or in the steam space inside the boiler. The feed water flowing through the tubes absorbs the heat from the steam flowing outside the tubes, and conducts this heat back into the boiler.

Before entering the superheater "P" the steam is led through a nest of tubes (arranged within governor "R") through which part of the feed water flows. The quantity of feed water is regulated by a three-way valve "3". On cooling down the steam forms a fine mist of vapours, which must first be evaporated in the superheater, whereby the temperature of the steam is regulated and at the same



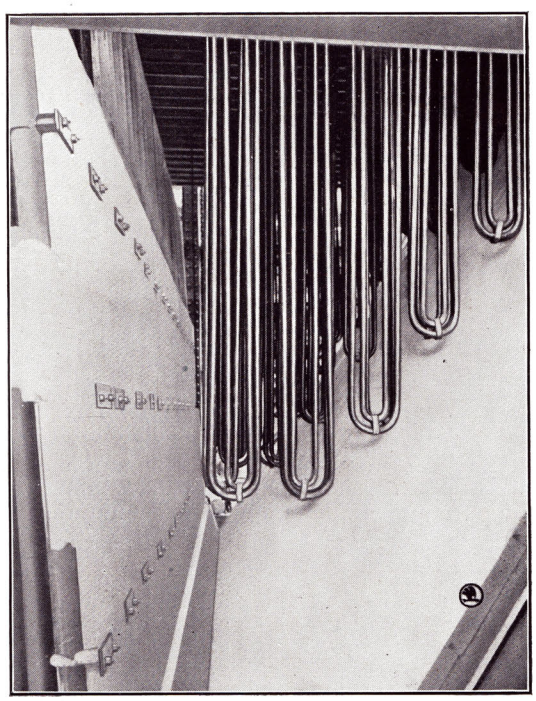


Fig. 42. Assembling a Vertical Superheater of a High-Pressure Boiler (66 atm. or 940 lb. per sq. in.).
Fig. 43. Vertical Superheater in the Boiler Flue.

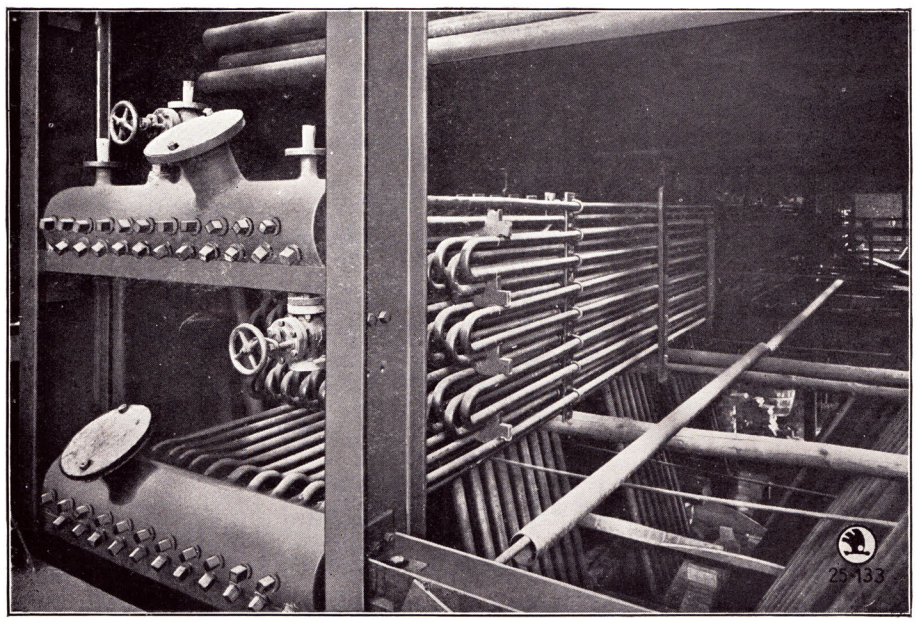


Fig. 44. Assembling a Horizontal Superheater.

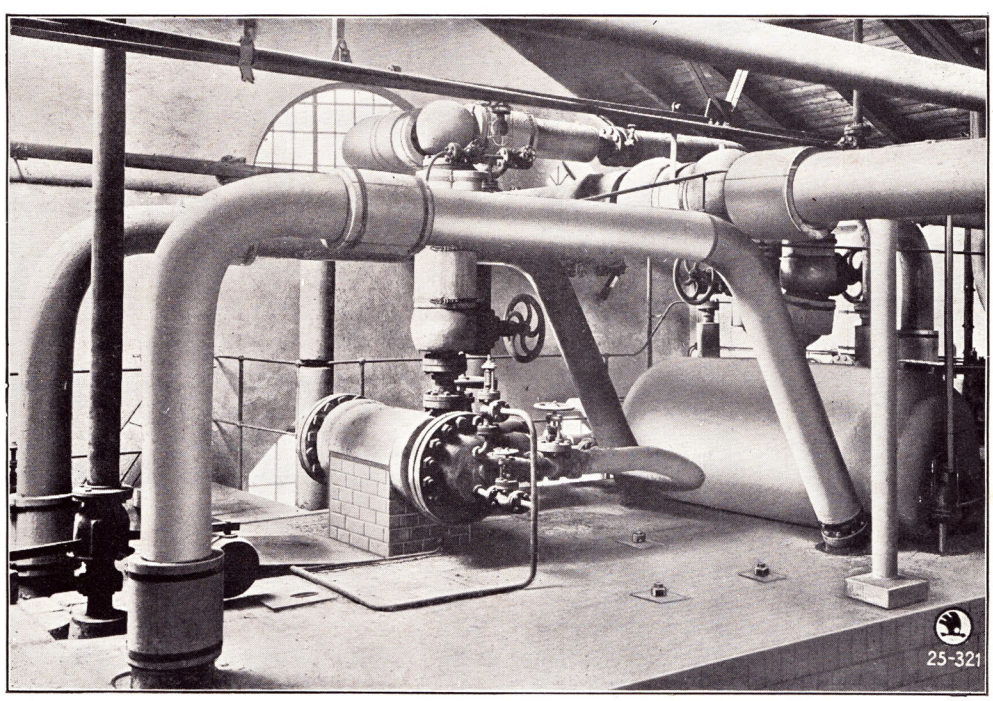


Fig. 45. Peča Steam Temperature Regulator on a High-Pressure Boiler (36 atm. or 512 lb. per sq. in.).

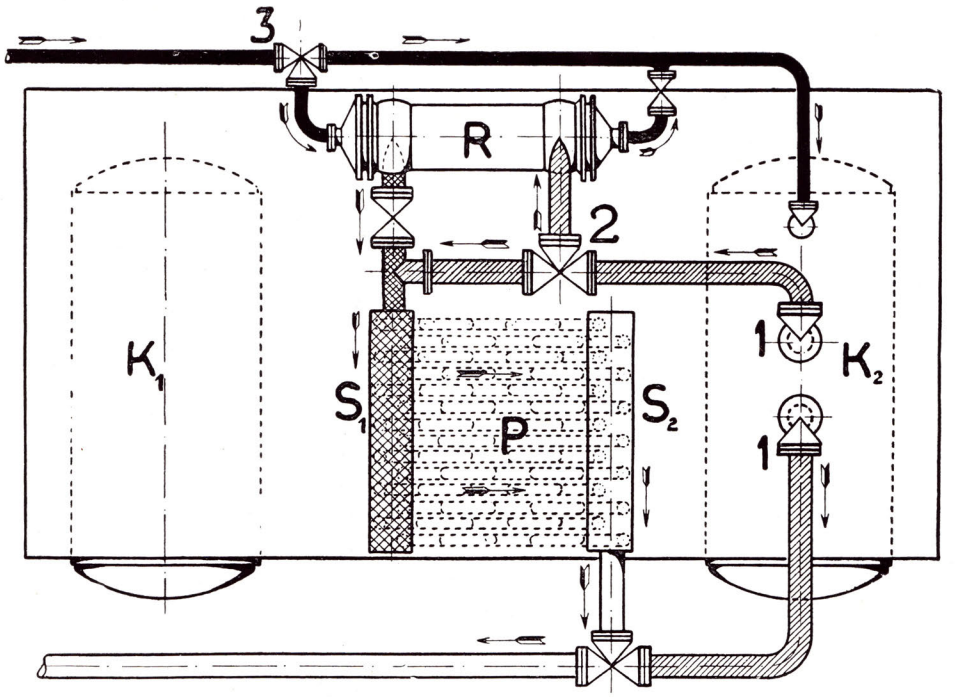
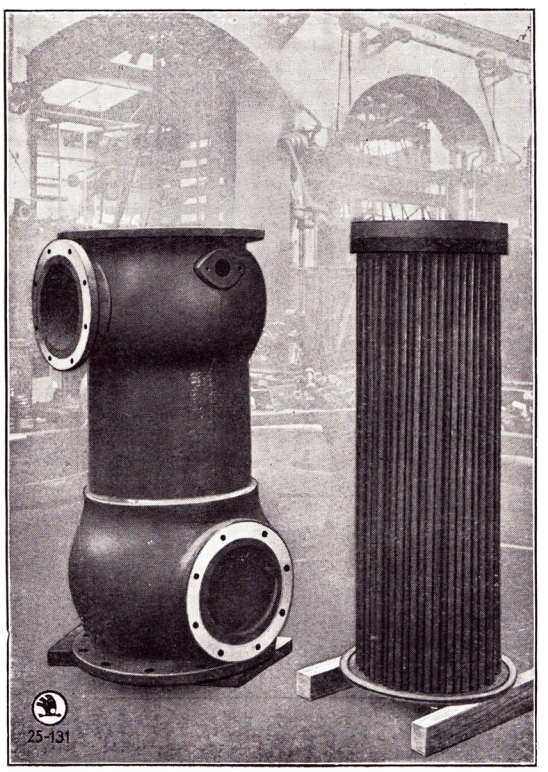


Fig. 46. Arrangement of a Peča Steam Temperature Regulator.



Saturated steam. *Steam moistened in the regulator.* *Superheated steam.* *Feed water.*

K_1K_2 — *Upper drums of a steep-tube boiler.*
R — *Steam temperature regulator.*
S_1 — *Saturated steam header.*
S_2 — *Superheated steam header.*
P — *Superheater coils.*
1 — *Main supply steam valves on the boiler.*
2 — *Three-way valve for switching the regulator R on and off.*
3 — *Three-way valve for regulating the feed water running through the governor.*

Fig. 47.
Regulator Shell with Tube Nest removed.

time the superheater is also protected. This is the principal difference as compared with other systems, in which the superheated steam is generally cooled behind the superheater, thus exposing the superheater coils to higher temperatures. The fine mist evaporates without difficulty in the superheater and leaves no solid residues. In the case of steam regulation by injecting water it may happen that the larger drops leave the superheater without being evaporated, apart from the fact that scale deposits in the coils.

THE ECONOMIZER.

In order to utilize the heat of the flue gases, which have a high temperature in highly-loaded boilers, economizers are arranged in the flues. In economizers the waste gases are cooled, as either the feed water (water economizer, i. e. economizer in the real significance of the word) or the air (air economizer or air heater) is preheated.

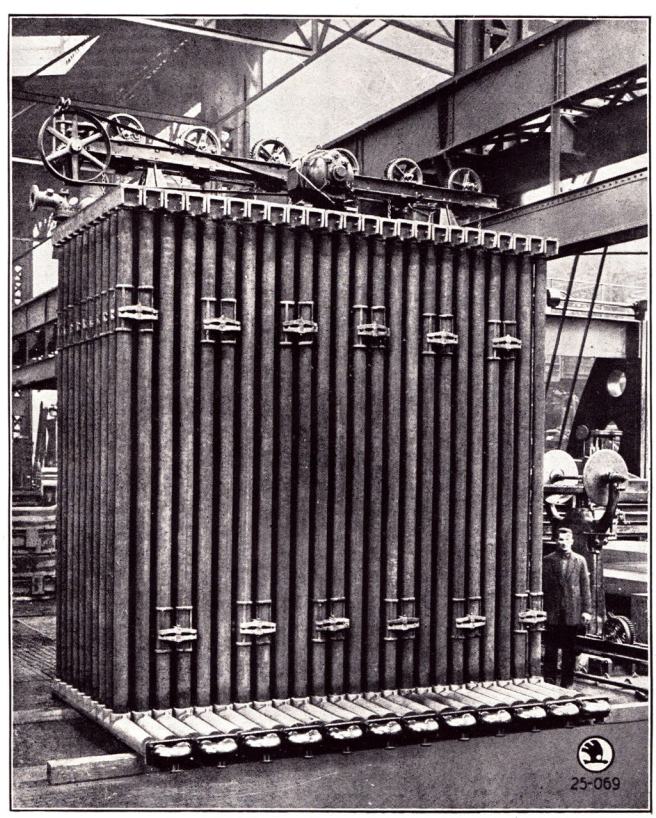


Fig. 48. Green Type Economizer.

Feed water economizers are made either of cast iron or of weldless steel tubes. An advantage which all economizers have in common is their great resistance to corrosion both inside and out. The tubes of cast-iron economizers are either ribbed or smooth.

As a special advantage of the ribbed-tube economizer the great strength of the tubes is to be emphasized, for which reason they are suitable for higher pressures. This and its relatively low price are the causes of the spread of this type in up-to-date boiler plants. The ribbed tubes are arranged horizontally and are interconnected by means of flanged cast-iron knees, which are outside the brickwork.

The general layout of a steep-tube boiler with ribbed-tube economizer and air preheater, is shown in Figs. 25 and 26.

Economizers with smooth tubes (so-called Green economizers) consist of a series of smooth, cast-iron tubes, 6 to 12 of which are pressed hydraulically into cast-iron headers, and together form the so-called register.

In our design (according to Münziger's patent) these registers are alternately longer and shorter, so as to ensure between the individual water headers a sufficiently large cross section for the waste gases to come out in the direction of the tubes, whereby an advantageous arrangement of the waste gas conducts is the result. The tubes are cleaned by means of an electrically-driven soot-scraping device or, in the case of up-to-date stoking with perfect combustion, where it is only necessary to remove the dust and soot, by means of soot blowers.

Economizers with weldless tubes consist of a suspended nest of weldless tubes, which are expanded on both sides into riveted or forged drums, and which, therefore, can easily be connected organically with the boiler by means of a few expanded tubes (both in the water space and in the steam space). These economizers are specially suitable where considerable steam formation in the economizer is to be expected.

As steel tubes are more subject to rust formation than cast-steel tubes (on the outside on account of the moisture condensed from the waste gas and inside through gages arising from the feed water), we avoid this drawback by feeding the boilers only with deaerated water, preheated to a temperature of above 100° C. (212° F.). When these precautions are observed, corrosions are fully precluded.

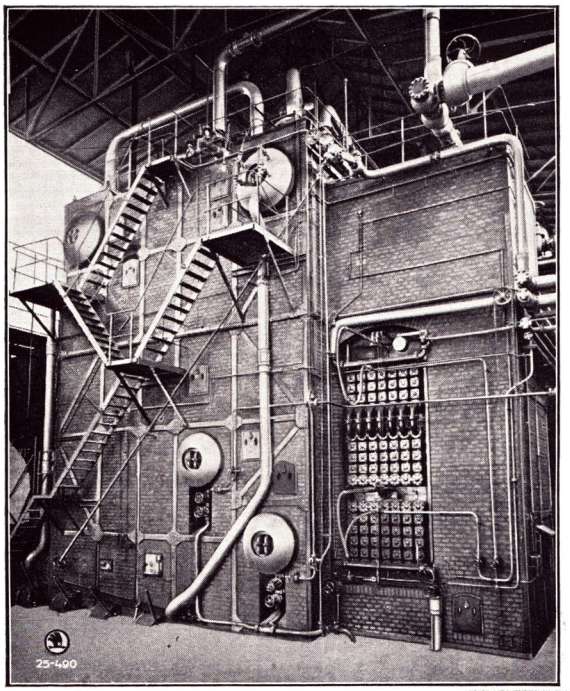


Fig. 49. High-Pressure Boiler with Ribbed-Tube Economizer.

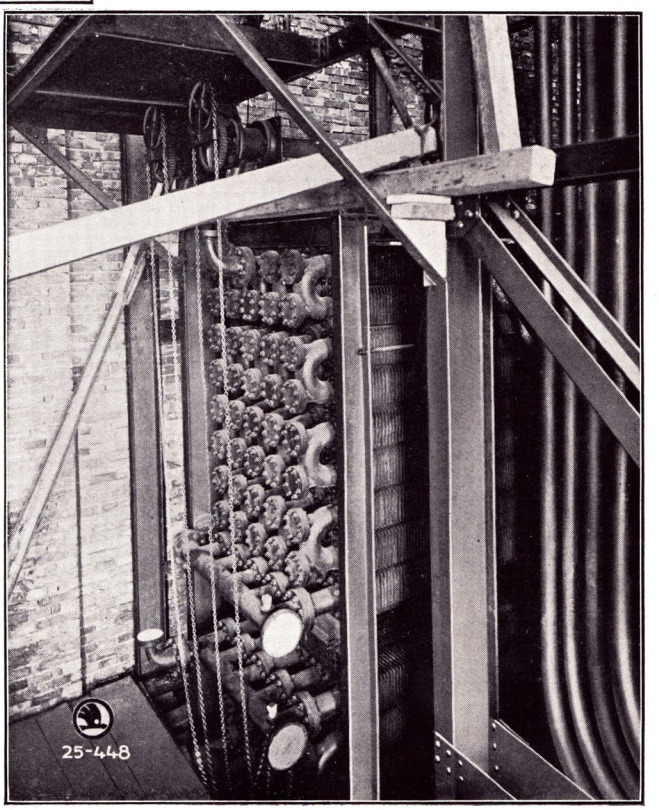


Fig. 50. Ribbed-Tube Economizer with Soot-Blowing Equipment. (Testing Pressure 120 atm. or 1710 lb. per sq. in.)

AIR HEATERS.

Air heaters are recommended for fuels of low calorific value and especially for fuels high in moisture. We manufacture a plate type heater, consisting of several strong welded sheet pockets. The air is forced by means of a ventilator through the air heater in counter current with the flue gases, and the preheated air is then led under the grate. The air heaters usually offer great resistance to the flue gases, so that nearly always a mechanical draught equipment is required.

GRATES AND FURNACES.

In planning grates the designer endeavours to construct such grates that are suitable as far as possible for various fuels. In this respect we have attained notable success, as on our grates it is possible to burn fuels of quite different properties. This endeavour is, of course, subject to limitations, and, in extreme cases, it is not always possible to attain equally good combustion of various kinds of coal on one and the same grate. For this reason we construct 3 types of mechanical grates:

1. Škoda-Weck travelling chain grates.

2. Lomshakoff mechanical overfeed stoker (platform type).

3. Škoda-Pluto mechanical overfeed stoker (inclined hollow fire bars type with forced draught).

In addition to the above-mentioned types of grates we construct, especially for smaller boilers where mechanical grates would be too expensive, fixed *plane grates,* eventually also in connection with an automatic stoking device, and *stepped grates* for lower grade fuel.

Forced draught is used with chain grates for low grade fuel, and with Pluto and Lomshakoff overfeed stokers.

On the basis of careful tests over a period of many years with all kinds of fuels, the circumstances under which each of the above-mentioned types of grates functions most satisfactorily can be ascertained reliably. Therefore we are in the

position to choose the particular grate which is most suitable in every respect for the prescribed fuel. For fuels the properties of which are at present unknown, we either analyse them in our research institute or make evaporation tests in our works. In all our grates we have the principle of distributing the air for combustion most favourably, so that they can work with a minimum of air excess, and so attain the highest degree of efficiency in combustion. Of course we also take care to have a suitable regulation of air excess, so that the high degree of furnace efficiency is maintained even with small boiler loads.

By using special fireproof cast iron and suitable design in order to ensure good cooling of the grate, we limit the wear by burning down of the fire bars to a minimum, and by means of massive finish of the grate and grate drive preclude any damage which could be caused by bending, clinker, etc. In order to facilitate the replacement of parts subject to unavoidable normal wear, these parts are made easily interchangeable. As a rule only small components need be replaced, and these changes can be carried out in the shortest possible time.

In accordance with modern furnace design we construct *pulverized-coal equipment,* either with the unit or central mill system. The advantages of this equipment are well known and will be enumerated later on.

(a) ŠKODA-WECK TRAVELLING CHAIN GRATES.

The travelling chain grate is a universal grate which is suitable for nearly all fuels: with natural draught for larger sizes of coal and with forced draught for coal dust.

The grate surface (Fig. 51) is formed of thin fire bars (6) which are set in frames (7) of 2 section irons. The frames are carried by steel chains (8) which are stretched between two sprocket wheels (3), the front drum being the driving drum. Both the chains and the grate frames are supported by rolls (11). The fireproof cast fire bars are very thin and relatively high, so that they can be cooled easily and efficiently by the current of air. The small gaps between the individual fire bars prevents even the smallest particles of fuel falling through. The

arrangement of the grate bars results in regular distribution of the air. The excess of air can be kept at the necessary height, thus giving a high degree of efficiency of the furnace.

By dividing the grate into driving chains, grate frames, and separate fire bars, the replacing of burnt-out fire bars is greatly facilitated even during working. The clinker is separated at the rear end of the grate by means of a cast-steel slag scraper (9), and then it falls into the ash-pit. These slag scrapers are also easily interchangeable. For overhauling or larger repairs the whole grate, which rests on four wheels, can be removed.

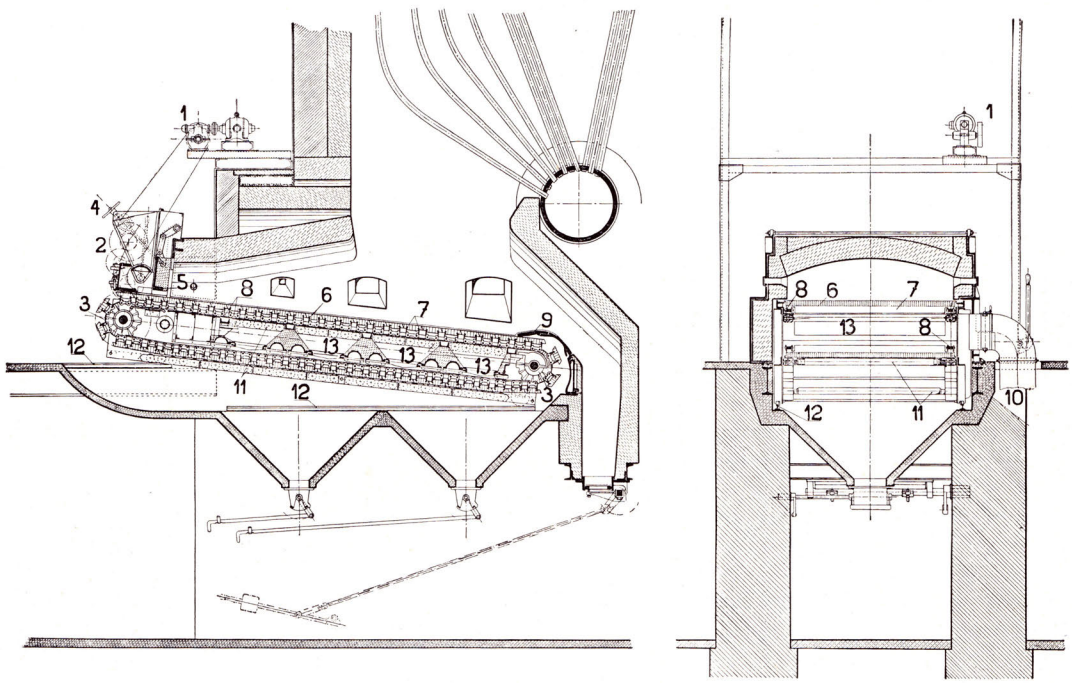


Fig. 51. Section of a Travelling Chain Grate (Škoda-Weck) with Forced Draught.

1. *Motor with worm wheel gear.*
2. *Gear.*
3. *Sprocket wheels.*
4. *Hand wheel.*
5. *Slide plate for regulating the layer of fuel.*
6. *Fire bars.*
7. *Fire bar frame.*
8. *Steel driving chain.*
9. *Slag scraper.*
10. *Combustion air inlet.*
11. *Rolls for equalizing the weight of the grate bars and chain.*
12. *Rails for drawing out the grate.*
13. *Air chambers.*

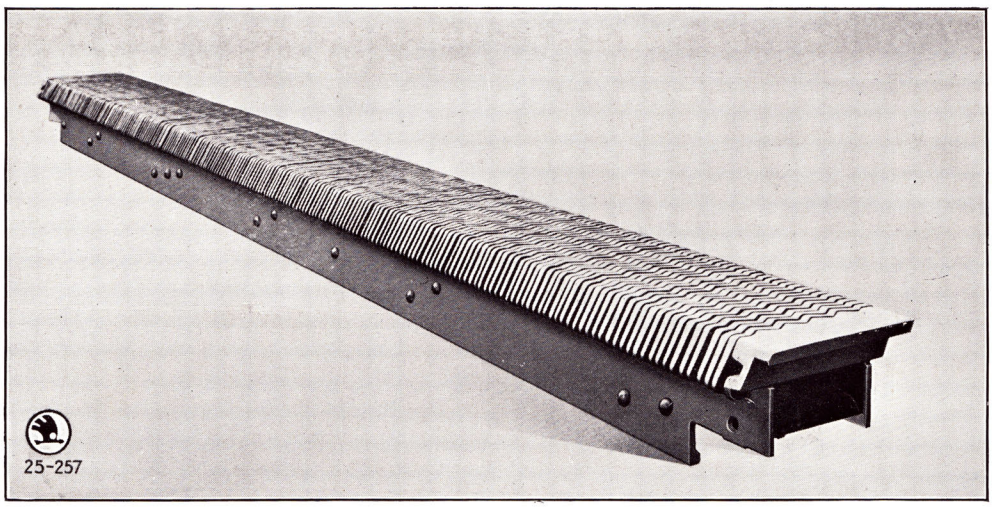


Fig. 52. Fire Bar Frame for a Travelling Chain Grate.

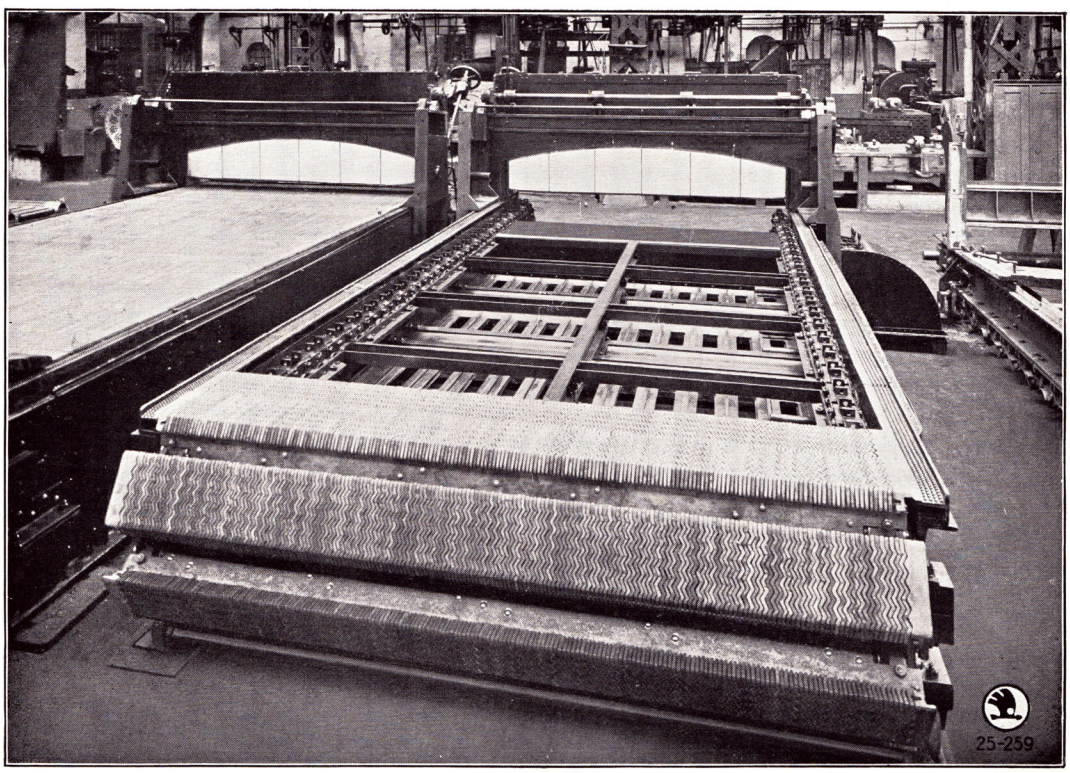


Fig. 53. Travelling Chain Grate with Fire Bar Frame partly Drawn out and Uncovered.

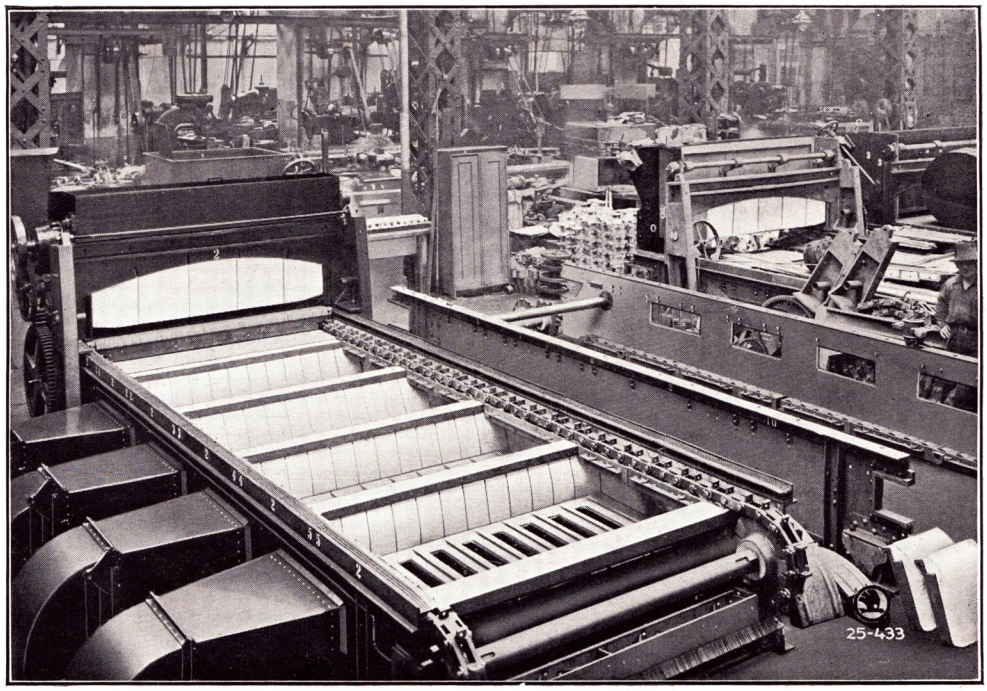


Fig. 54. Travelling Chain Grate with Fire Bar Frames Drawn out to Show the Air Chambers and Inlets with Regulating Dampers.

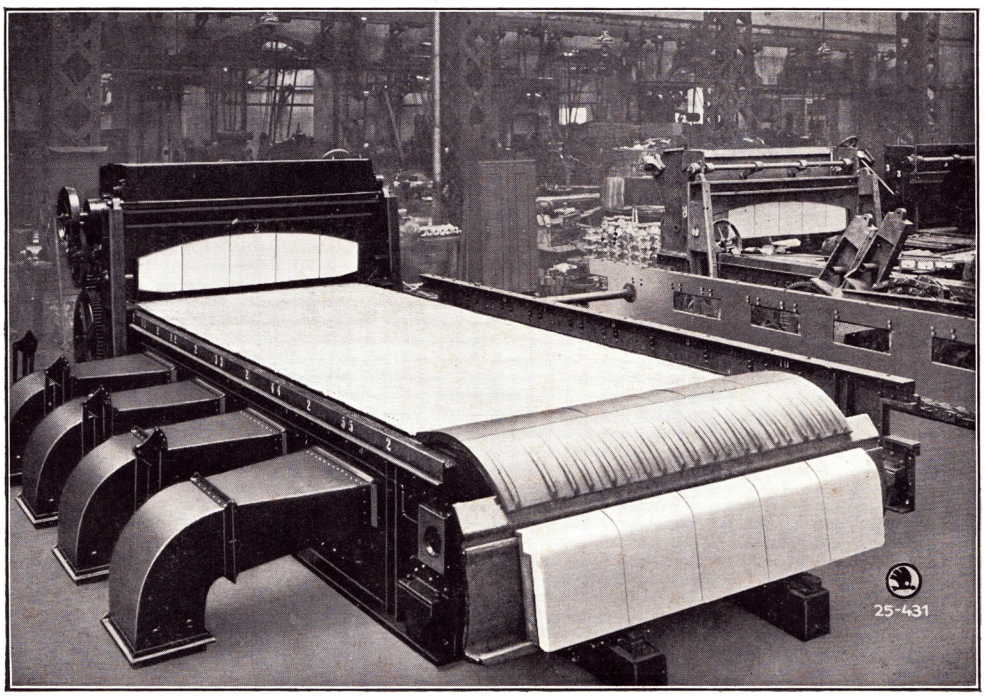


Fig. 55. The Same Grate with Fire Bar Frames and Clinker Scrapers.

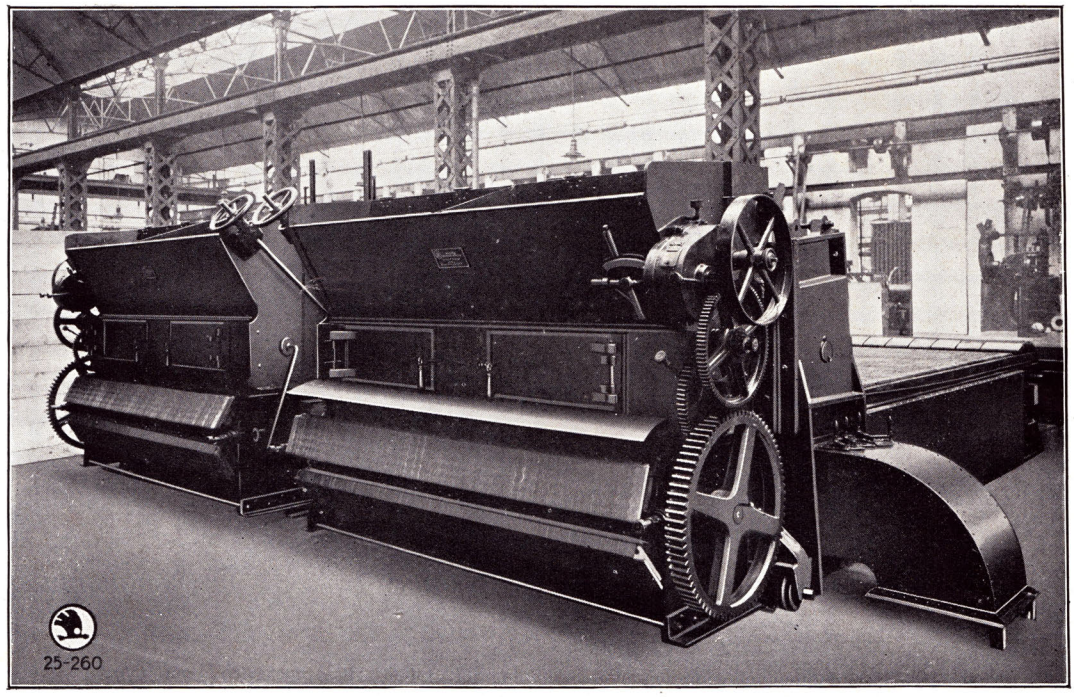


Fig. 56. Travelling Chain Grate seen from the Front.

The quantity of fuel can be regulated easily and within large limits, on the one hand by regulating the height of the layer of fuel by means of a slide plate (5), on the other hand by regulating the speed of the grate movement by means of a gear (2), which is driven by an electric motor (1) through a worm wheel gear. Its power requirements are very small (about $^1/_{10}$ to $^1/_4$ h. p. for 1 m^2 of grate surface). The quantity of combustion air is regulated by dampers for each individual air chamber, with both forced and natural draught grates (and of course by regulating the main flue damper or the induced draught fan). In the case of natural draught grates the air admission is regulated by means of a sliding grid of movable flat iron bars underneath the fire bars, which at light load throttle the air admission to a greater extent at the rear end of the grate.

(b) LOMSHAKOFF MECHANICAL STOKERS.

The *"Lomshakoff"* forced-draught overfeed stoker consists of a number of stoker platforms arranged one above the other in terraces. These stoker surfaces have a swinging motion, whereby following stoker platforms always move in opposite directions. After every forward movement part of the fuel falls from the upper stoker platform onto the lower, so that on further swinging movements of the stoker surfaces the fuel is gradually pushed forward in the direction of the ash funnel.

This manner of stoking offers the following great advantages: The height of the fuel depends only on the length and inclination of the stoker platforms. Therefore the height of the layer is the same at the end of the stoker, where the fuel is already burnt, because the places where combustion is more rapid are automatically filled up. Further the stoker movement as above described has the result that the fuel mixes and that, when the fuel falls from the individual stoker surfaces, any caked pieces are broken up.

The individual stoker platforms consist of cast-iron frames in which wire gauze and thereon cast-iron grids are arranged. The small gaps in the grids are filled up with fine-grained, refractory material, on which the fuel lies. In this way it is fully impossible for fuel to fall through. In addition to the grate surface being refractory, the fine-grained material gives a uniform and perfect distribution of the combustion air which is blown by a forced draught fan in the air chamber under the stoker. This also prevents fuel dust and ashes being entrained by the current of air. Also the air excess is very low (12 to 15% CO_2) with these stokers. In case of short fire the air admission under the last grate elements can be fully shut off.

Lomshakoff stokers with their characteristic advantages are specially suitable for fine-grained or even dust fuels of low grade and with high water or ash content. The results obtained with this stoker are unique. A special booklet gives an exhaustive description of this stoker together with numerous particulars about the efficiency obtained with various kinds of fuel.

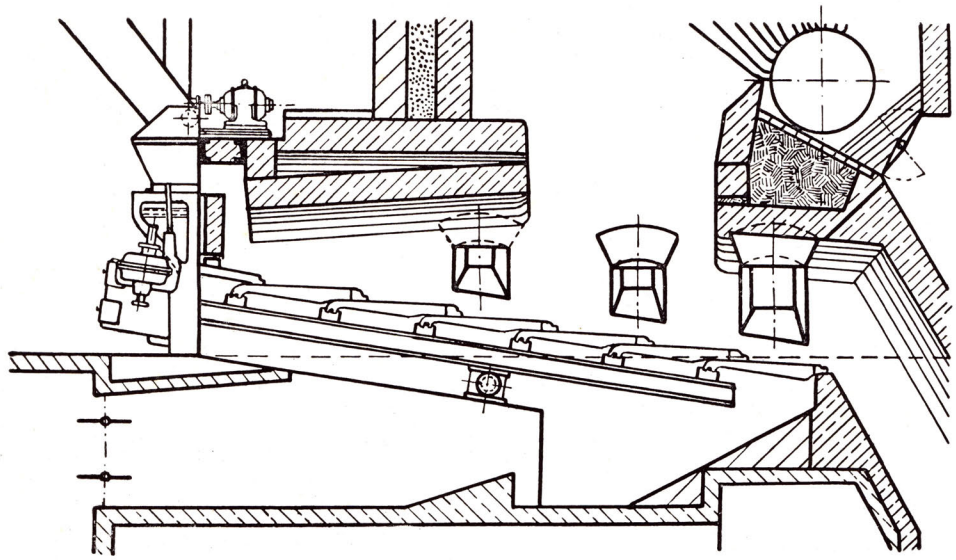


Fig. 57. Section of a "Lomshakoff" Overfeed Stoker.

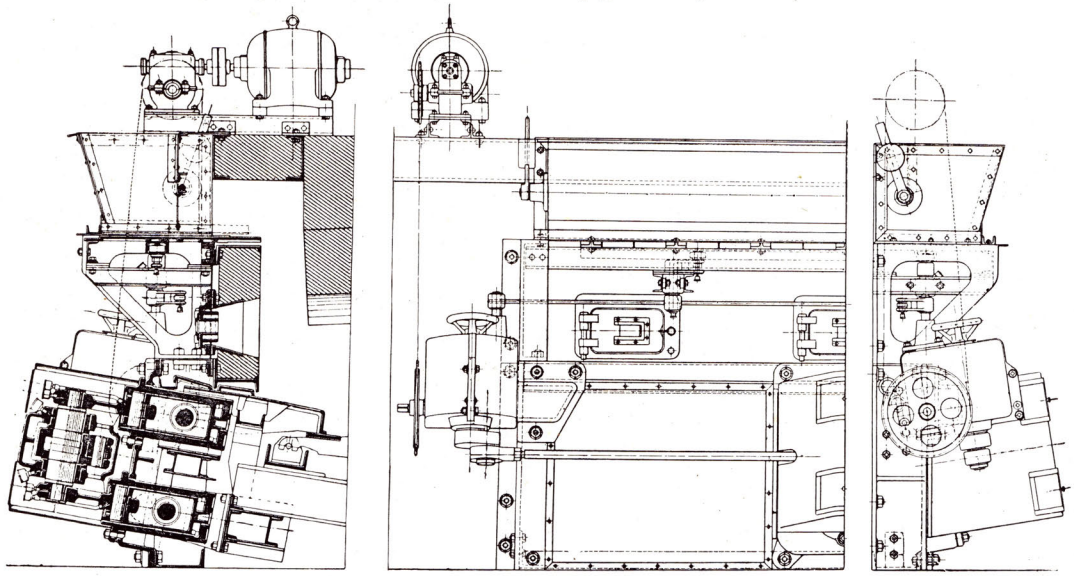


Fig. 58. Driving Device of a "Lomshakoff" Overfeed Stoker.

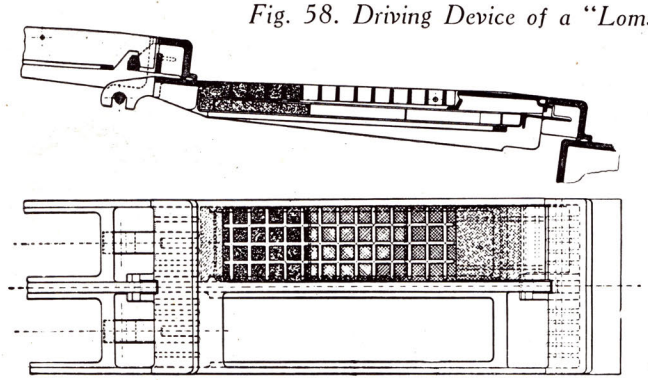


Fig. 59. Section through Stoker and Platform.

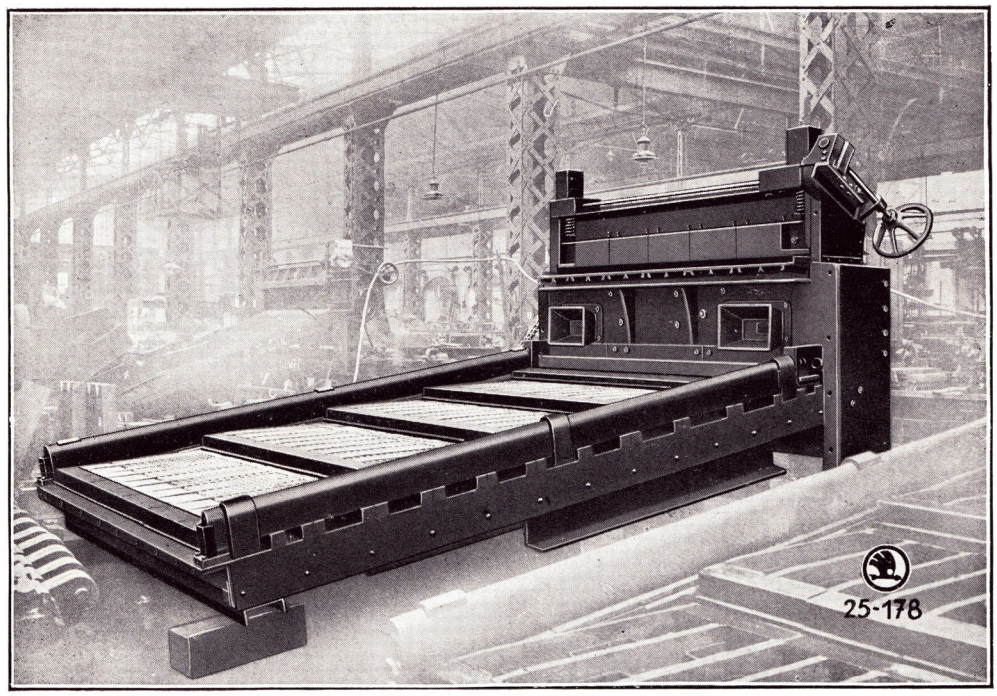


Fig. 60. "Lomshakoff" Overfeed Stokers in our Workshops.

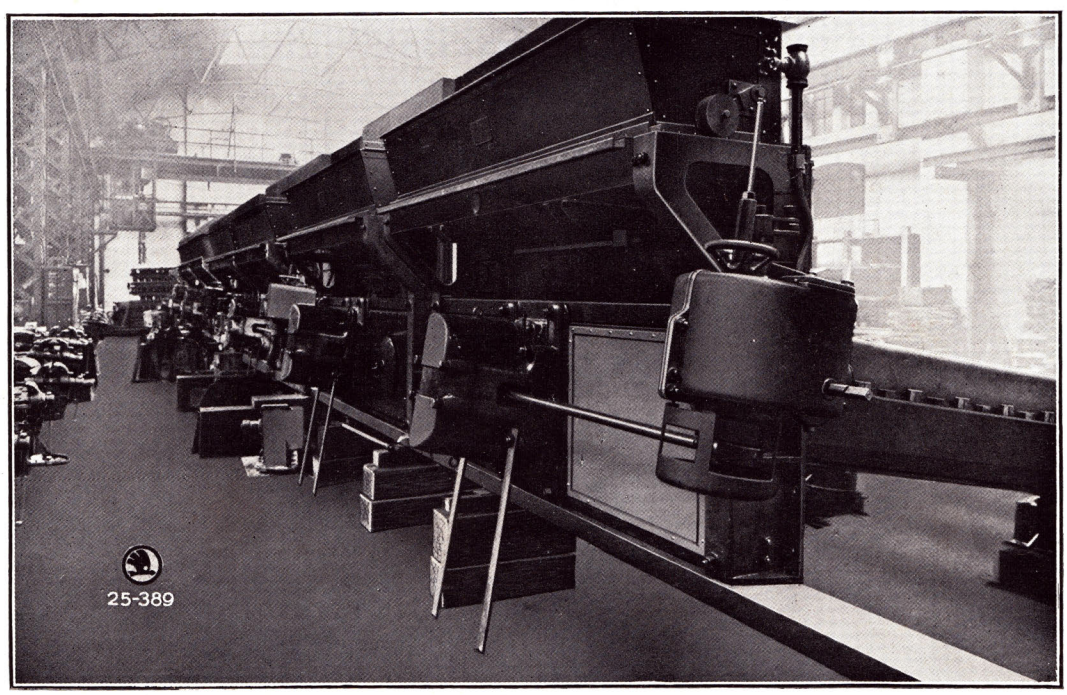


Fig. 61. "Lomshakoff" Overfeed Stokers in our Workshops.

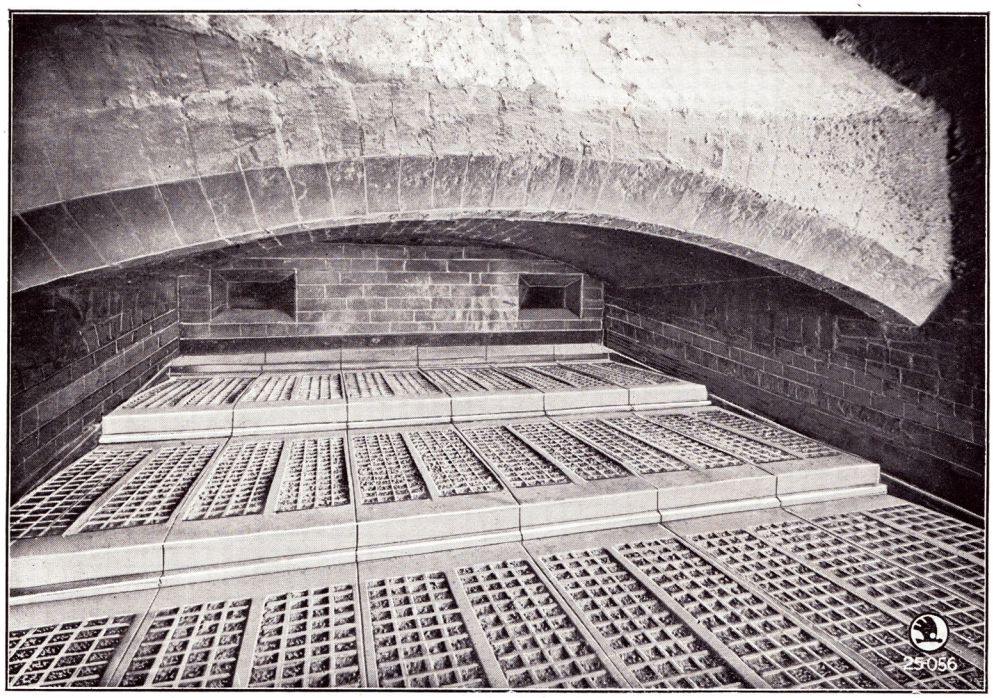


Fig. 62. Grate Surface of a Lomshakoff Stoker.

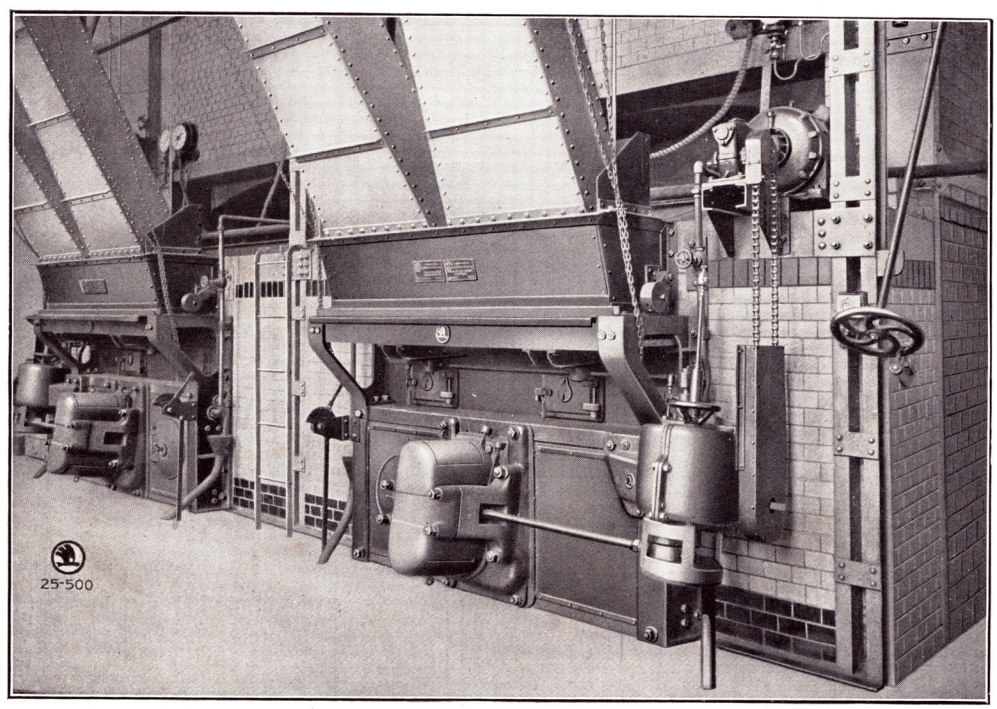


Fig. 63. Steep-Tube Boilers, Heating Surface 250 m² (2700 sq. ft.) Each, Pressure 32 atm. (460 lb. per sq. in.), equipped with Lomshakoff Stokers.

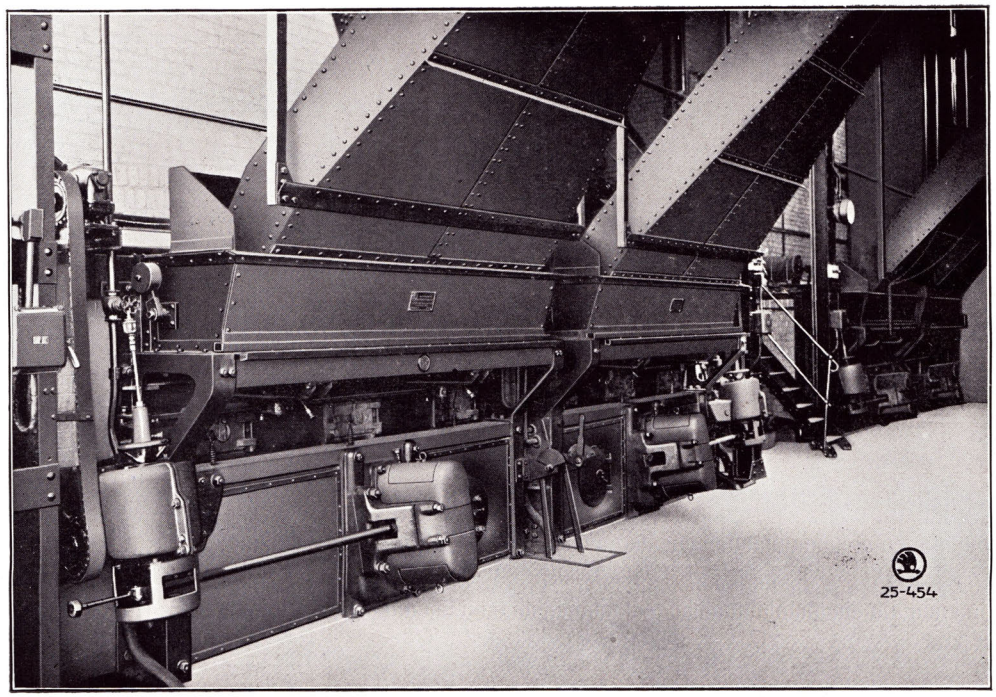


Fig. 64. Lomshakoff Overfeed Stokers.

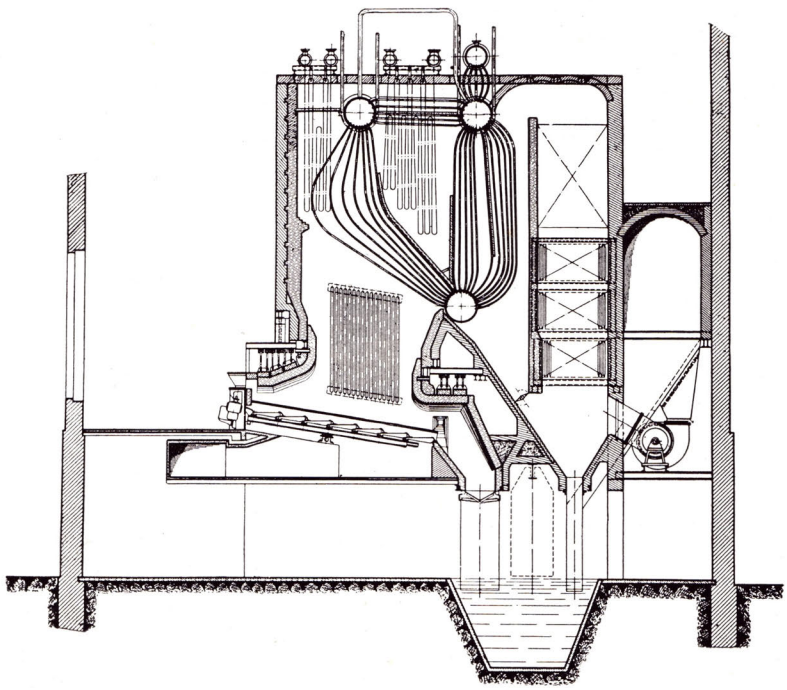


Fig. 65. Steep-Tube Boiler, Heating Surface 1200 m² (13,000 sq. ft.), Pressure 60 atm. (850 lb. per sq. in.), with Lomshakoff Stokers of 50 m² (550 sq. ft.) Surface, for Low-Grade Coal of 2800 cal. (4850 B. Th. U. per lb.). Divided Superheater, Ribbed-Tube Economizer, and Air Preheater.

(c) ŠKODA-PLUTO MECHANICAL OVERFEED STOKER.

The stoker consists of a number of hollow fire bars (1) movable in a horizontal direction, and inclined at an angle of 21° to the horizontal. The upper surface of the fire bars, coming in direct contact with the fuel, is formed of a large number of interchangeable tuyeres (2) of special cast iron. The combustion air is forced through a cast-iron tube of elliptical section formed by two hollow supports (6), from where it comes to the fire bars (1) and then through the tuyeres to the fuel. By this means the combustion air is preheated and at the same time all parts of the stoker bars are efficiently cooled.

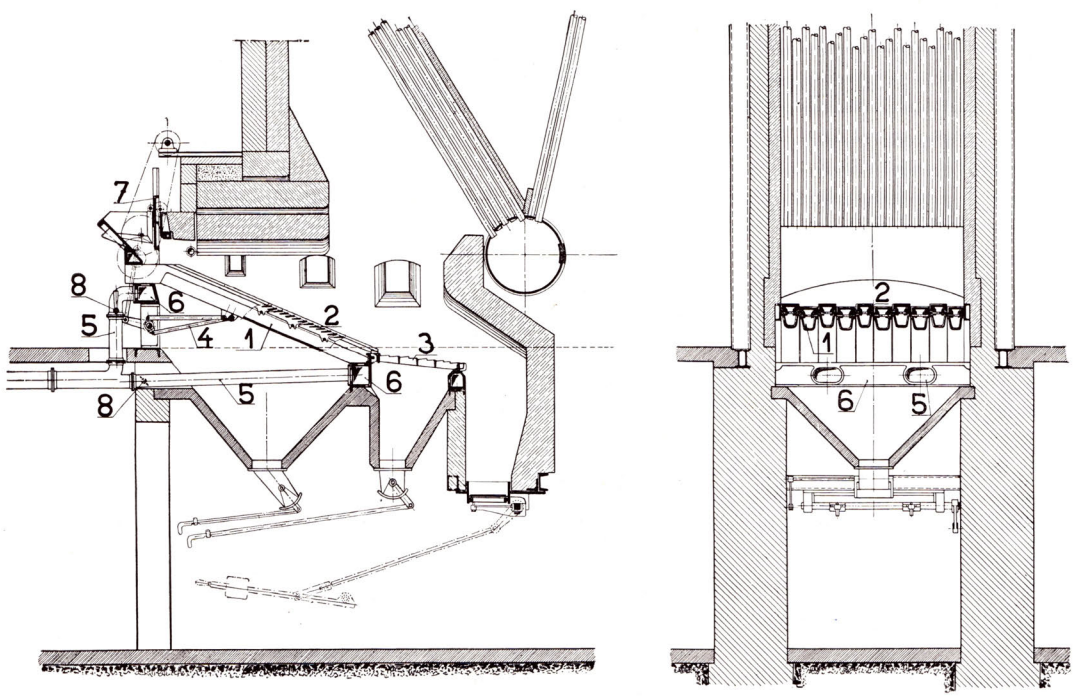


Fig. 66. Section of a Mechanical Overfeed Stoker with Hollow Fire Bars (Škoda-Pluto).

1. *Cast-iron fire bars.*
2. *Special cast-iron stoker elements.*
3. *Clinker grate.*
4. *Lever gear.*
5. *Cast-iron air piping.*
6. *Hollow cross support.*
7. *Slide plate for regulating the height of the layer of fuel.*
8. *Regulating flaps in the air inlet piping.*

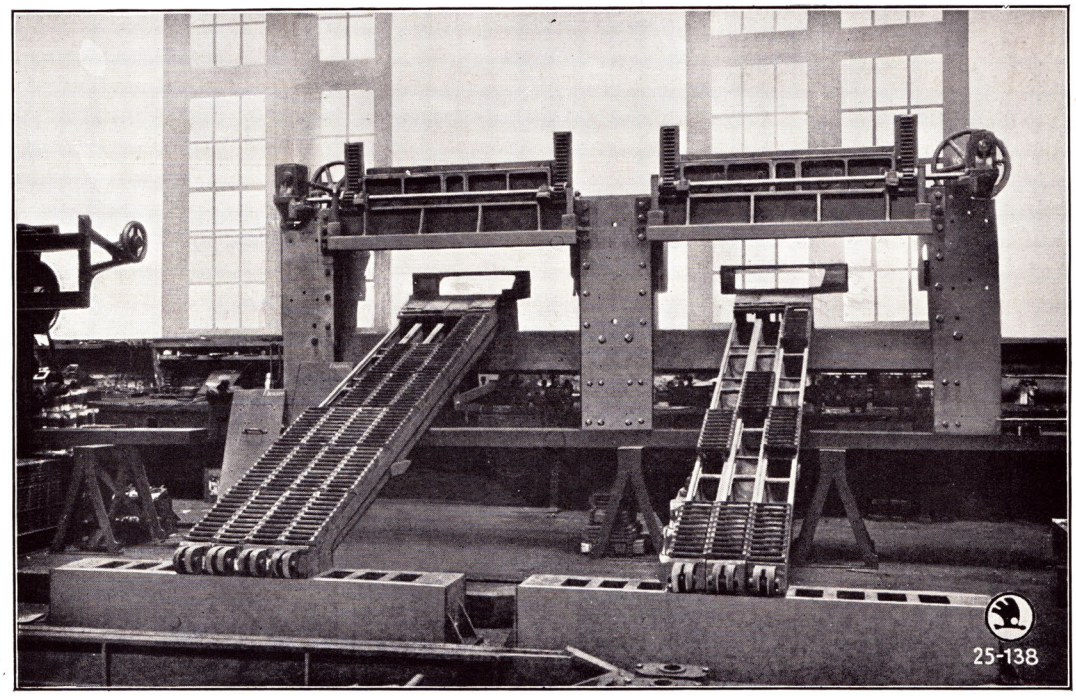


Fig. 67. Two "Škoda-Pluto" Mechanical Overfeed Stokers during Erection: Each with 10 Grate Frames, of which 4 (the grate in the left) and 3 (the grate on the right) are partly filled with Grate Elements.

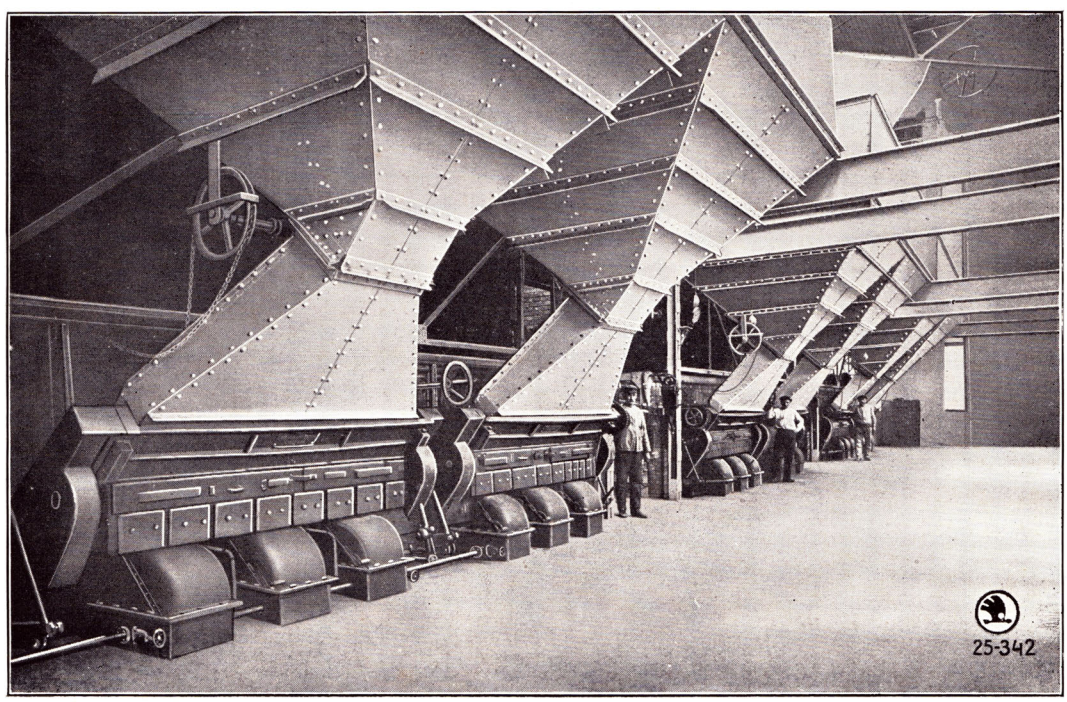


Fig. 68. Interior of a Boiler House with 6 Steep-Tube Boilers each with 275 m² (2960 sq. ft.) Heating Surface, equipped with "Škoda-Pluto" Stokers.

By means of a toothed wheel and rod gear the fire bars are given a reciprocating movement in such a way that adjoining bars always move in opposite directions, whereby caked coal and clinker are broken, mixed, and pushed forward to the ash-pit. At the lower end of the hollow fire bars a reciprocating clinker grate with slighter inclination is attached. On this grate the clinker burns down before being forced into the clinker pit.

This stoker is specially suitable for caking coal as the movement of the fire bars prevents the formation of cakes of clinker, and thereby assures complete combustion.

(d) STEPPED GRATES.

Stepped grates work with natural draught. Normally we construct them only for smaller boilers and for fuel of low heating value, in so far as the latter does not cake too much when burning. The individual steps are made of special

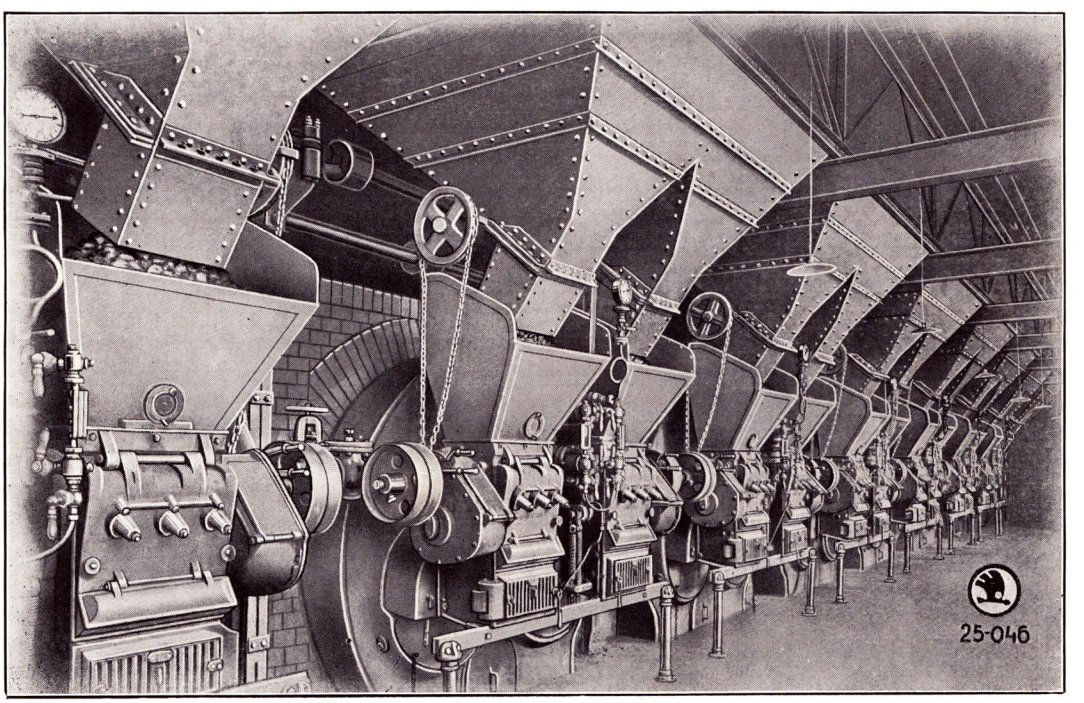


Fig. 69. Interior of a Boiler House with Flue Boilers. Horizontal Grates with Automatic Stoking Apparatus.

cast iron. The glowing fuel glides by its own weight down the steps onto a short horizontal grate where it burns to an end. By tipping the horizontal grate the ashes and clinker fall into the ash chute.

(e) HORIZONTAL GRATES.

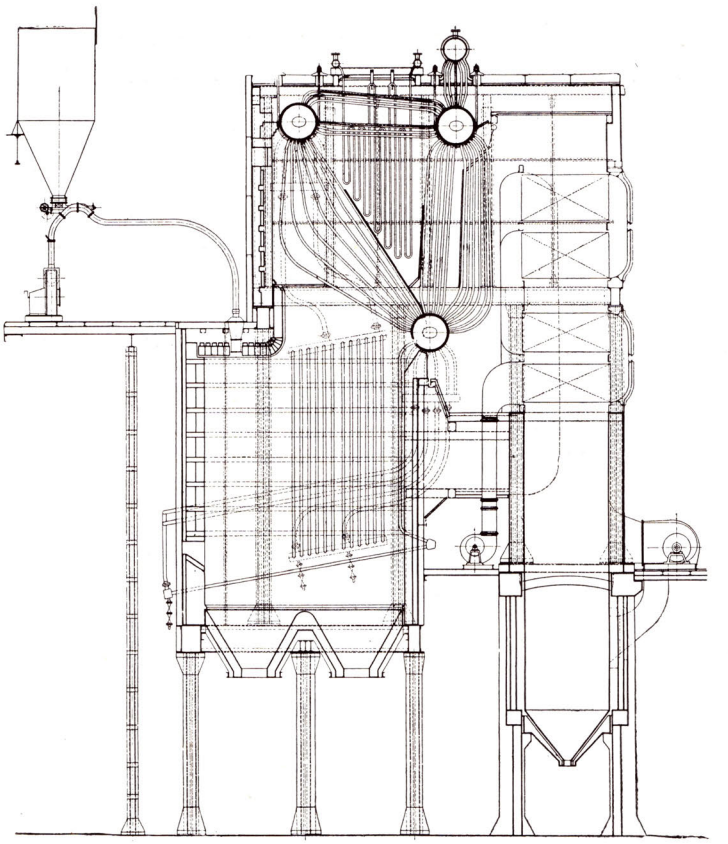
This type of grate is only for smaller boilers, especially for flue boilers and combined boilers, in which coal of better quality is always used. Very often we supply these grates with an automatic stoking apparatus (Fig. 69).

PULVERIZED-COAL FIRING EQUIPMENT.

The advantages of this modern firing method are well known. They are high efficiency, adaptability to different fuels, and the capacity to follow load fluctuations quickly. The high capital outlay and high operating and maintenance expenses, which constituted a serious handicap to pulverized-fuel firing as compared with stoker firing, have been considerably reduced by the development of direct firing from unit mills. By direct firing with drying in the mill through preheated air, much complicated equipment for drying, separating, and dust catching has been eliminated in the case of fuel high in moisture. The unit system broadened the field of the economical use of pulverized-coal firing even in small and medium-sized plants. In large boiler houses both the unit and central mill system are used.

The Škoda Works have had remarkable success in developing pulverized-coal burning equipment to suit any given service conditions. Fig. 70 shows a high-pressure boiler, delivered to a district heating plant (70 atm. or 1000 lb. per sq.

Fig. 70. High-Pressure Boiler for 70 atm. (1000 lb. per sq. in.), 1150 m² (12,000 sq. ft.), with Coal Bin, Screw Feeders, Vertical Burners, and Partly Water-Cooled Furnace.



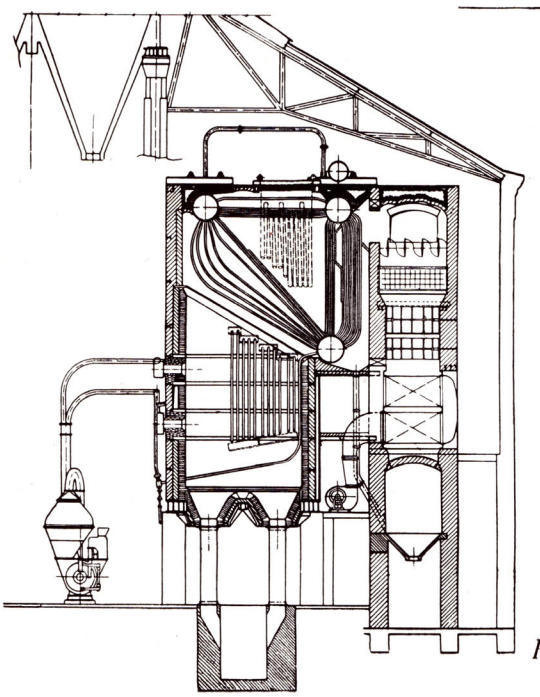


Fig. 71. High-Pressure Boiler for Direct Pulverized-Coal Firing, without Suspended Flat Arch.

in; 1150 m^2 or 12,000 sq. ft.), equipped with coal bin, screw feeders, vertical burners, and partly water-cooled furnace. Fig. 71 shows a high-pressure boiler of 1000 m^2 (10,764 sq. ft.) with direct firing and horizontal burners. Fig. 72 is a small water-tube boiler with semi-direct firing and mill drying. The small boiler in Fig. 72 has air-cooled walls, larger boilers (Figs. 70 and 71) have furnaces partly cooled with water tubes. The ash-pit is protected by a water screen.

For lining the furnace high grade firebricks are used. The walls of the furnace are held in the iron by elastic joints, so that they are able to expand freely under the influence of heat, and at the same time there is no danger of them falling off.

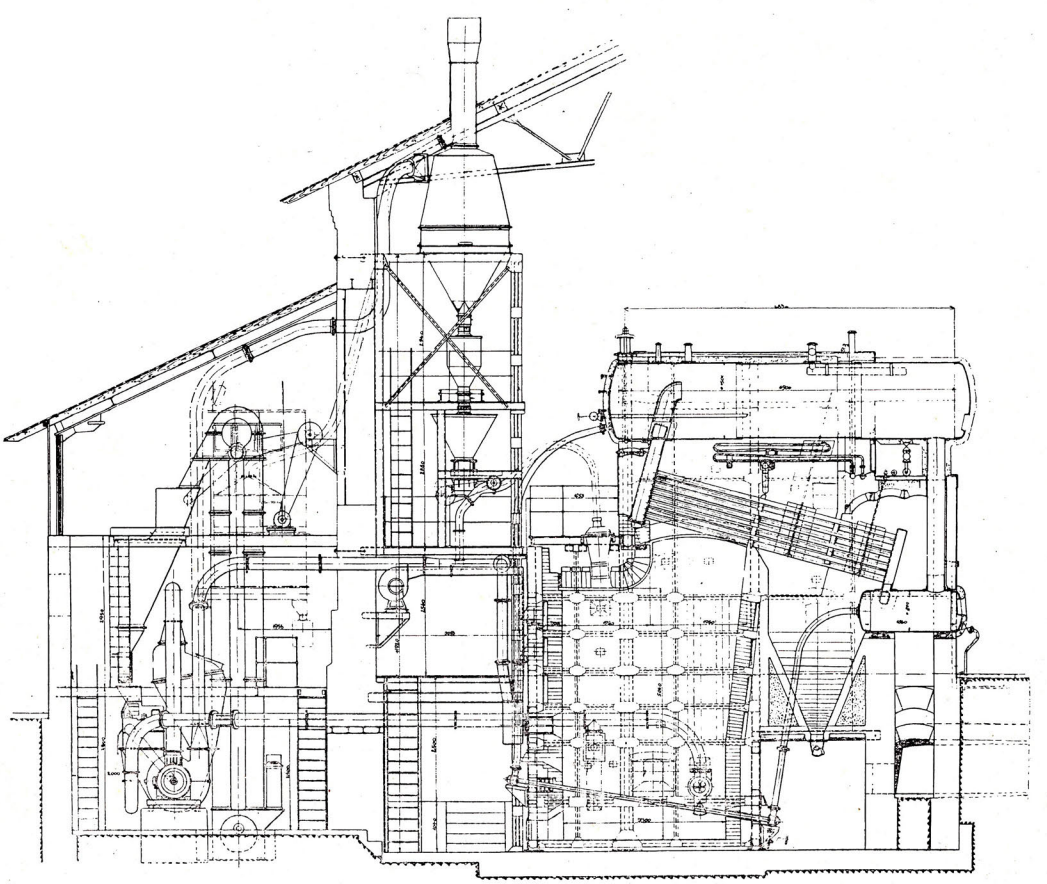


Fig. 72. Small Water-Tube Boiler with Semi-Direct Firing for Testing Purposes.

Fig. 73. Combustion Chamber with Water-Cooled Rear and Side Walls and Granulating Water-Screen.

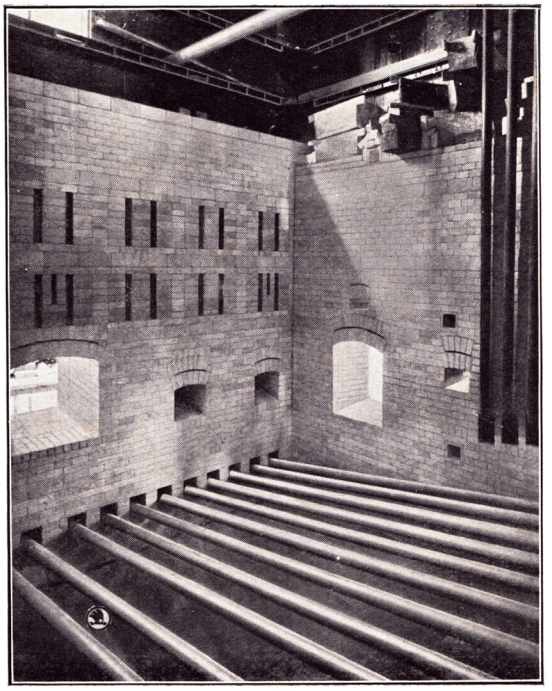


Fig. 74. Front Wall and Granulating Water-Screen of a Combustion Chamber.

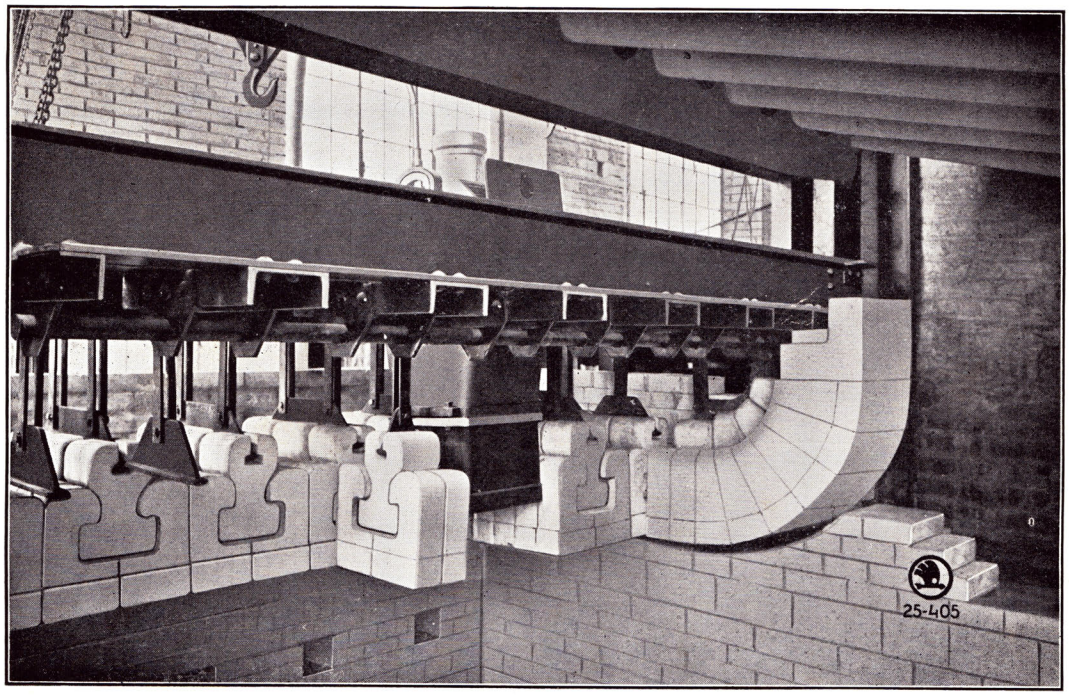


Fig. 75. Suspended Flat Arch of the Furnace.

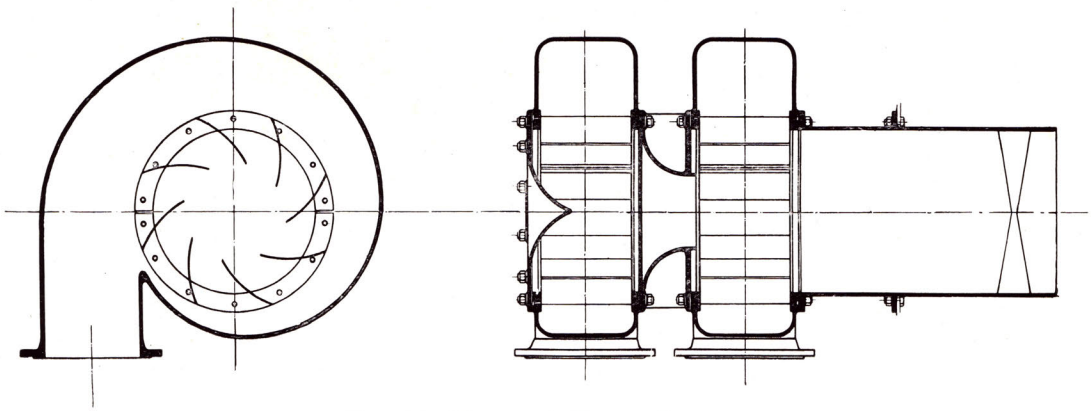


Fig. 76. Horizontal Rotary Burner.

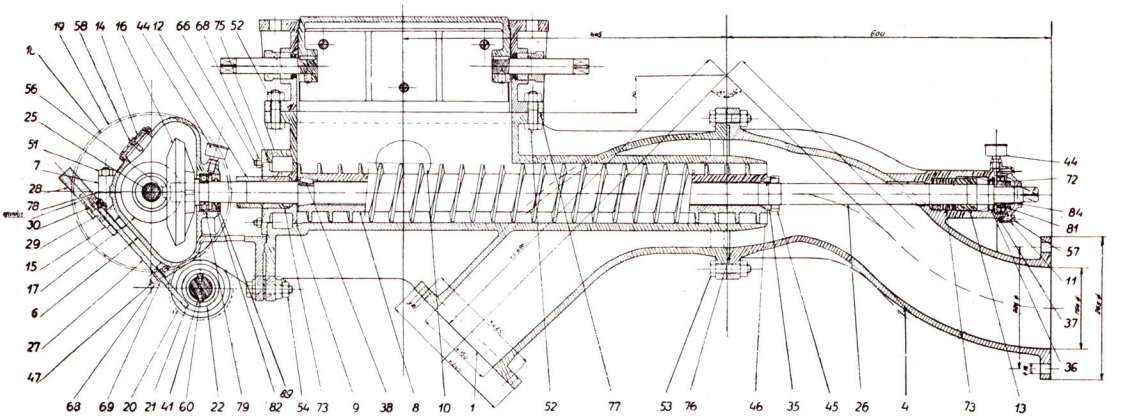


Fig. 77. Section through a Screw Feeder.

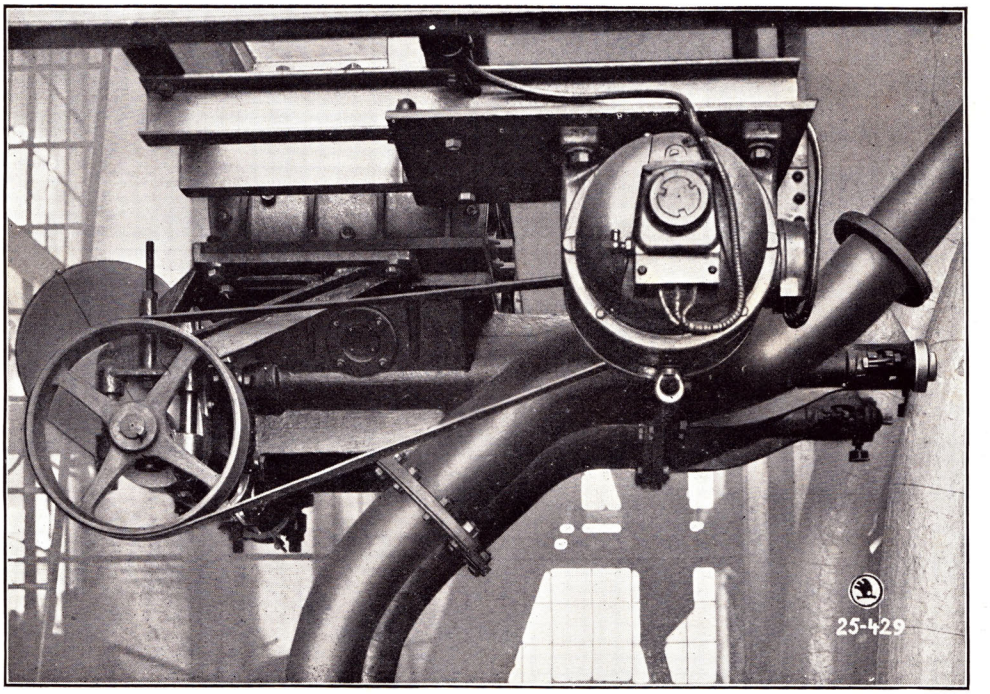


Fig. 78. Pulverized-Coal Screw Feeders.

In the majority of cases the furnace walls are protected by cooling tubes, which form part of the boiler itself. As a rule we use plain bare tubes with the best results. Figs. 73, 74, and 75 show some details of the furnace.

The whole furnace is seated on a solid frame of riveted steel sections. The outside insulation of the furnace can be executed in ordinary red bricks (in the case of small boilers), or can consist of a layer of insulating bricks and a sheet steel casing.

The burners are placed either vertically in a suspended arch (Figs. 70 and 72) or horizontally (Figs. 71 and 76) in the front wall or side walls. The vertical burner gives a longer U-shaped flame, while the horizontal whirling burner gives a shorter flame. In the latter case the suspended arch is not necessary, so that a simple and cheaper furnace design results, and the maintenance costs of the furnace are smaller.

In both cases their design leads to intensive mixing of air and pulverized-coal streams, so that a clear fire and a short flame results.

The pulverized coal is fed to the burners either directly from the pulverizer (Figs. 71 and 72) or from the bunker by screw feeders (Fig. 70).

Pulverized-coal screw-feeders are shown in Figs. 77, 78, 79, 80, and 81. The bearings are situated outside the housing so that no pulverized coal can get into them, and they are accessible when the feeder is running. The feeder can be driven by a normal a. c. squirrel-cage motor.

The gearing between the motor and the feeder gives two different speeds. For larger boiler units the feeders are combined in groups with a common frame for all feeders, which is placed below the bunker.

Each such group is driven by a common motor and gets air from the primary air fan through a common header.

The power consumption of the feeders depends mainly on the quality of the pulverized coal, and amounts to 0·3 to 1 kW per feeder. One lever serves both for starting and stopping the feeder and for changing the feeder speed. This is an exceptionally simple device for easy control of the plant. A still more flexible operation is secured by using a variable speed motor.

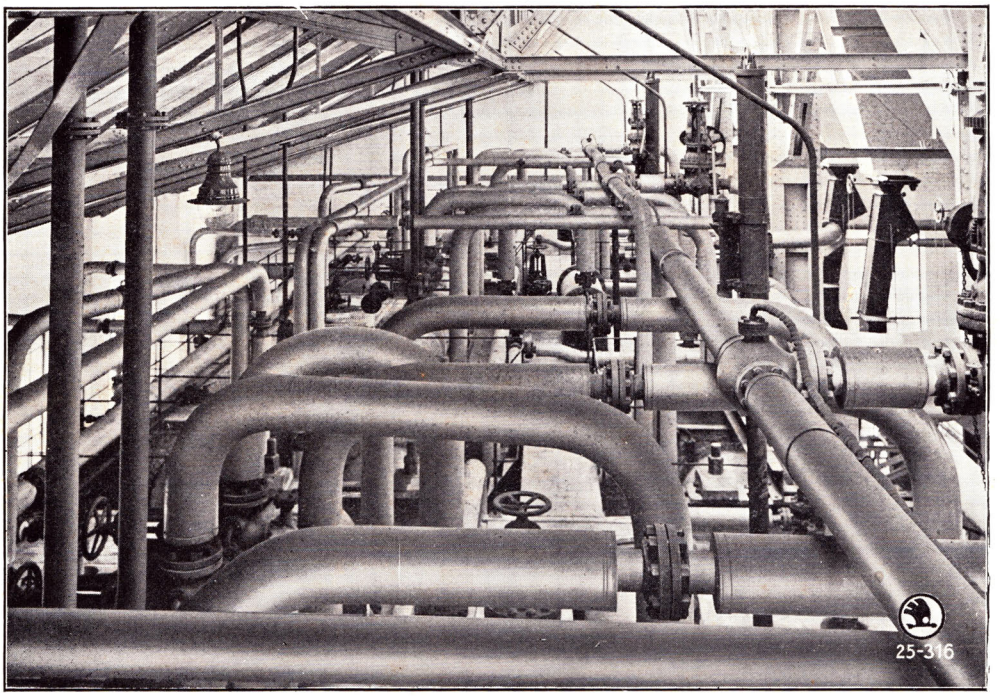


Fig. 85. Steam Piping of a High-Pressure Boiler Plant (36 atm. or 512 lb. per sq. in.).

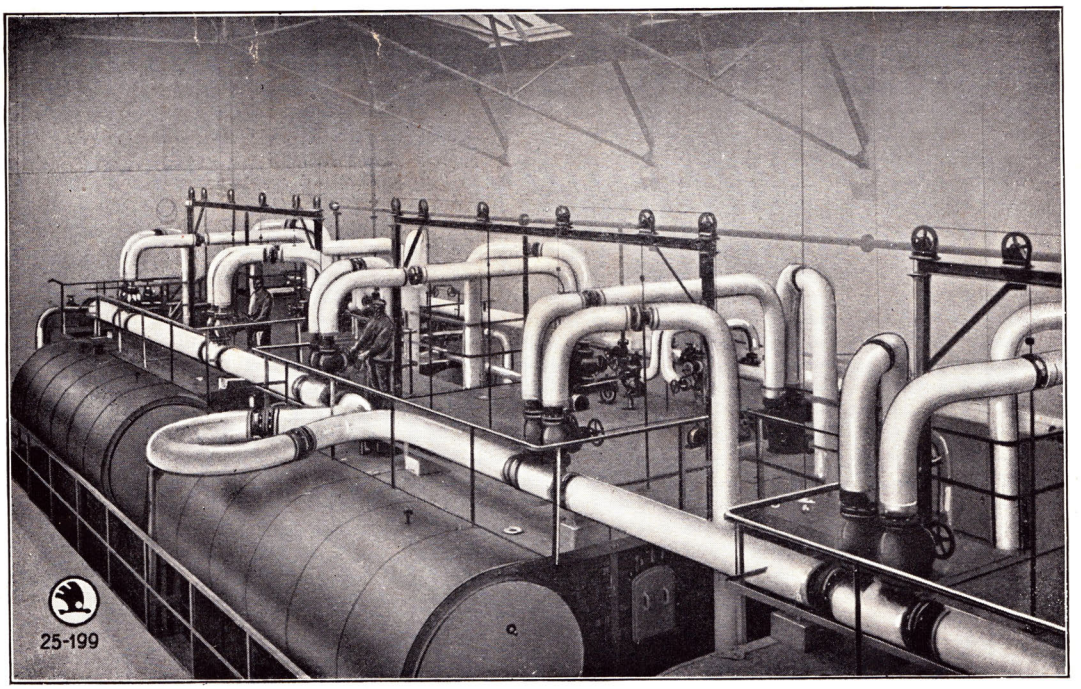


Fig. 86. Steam Piping of a Medium-Pressure Boiler Plant.

FEED PUMPS.

For small boiler outputs we generally use piston steam feed pumps, the working steam being used to preheat the feed water. For medium and large outputs we construct centrifugal feed pumps. The manufacture of these feed pumps is undertaken by a special department, which has brought them to a high state of perfection, not only with regard to their efficiency and quiet running, but also with regard to their safety in working and durability. Centrifugal pumps are driven either by electric motors or steam turbines.

For turbine drive our turbine works have developed a special type of turbine with reduction gear, the teeth of which are hardened and most carefully ground. The turbines are designed with forced lubrication and with oil cooling. This design assures a high degree of efficiency of the turbine and great reliability in working. These features make our turbo pumps superior to ordinary turbines

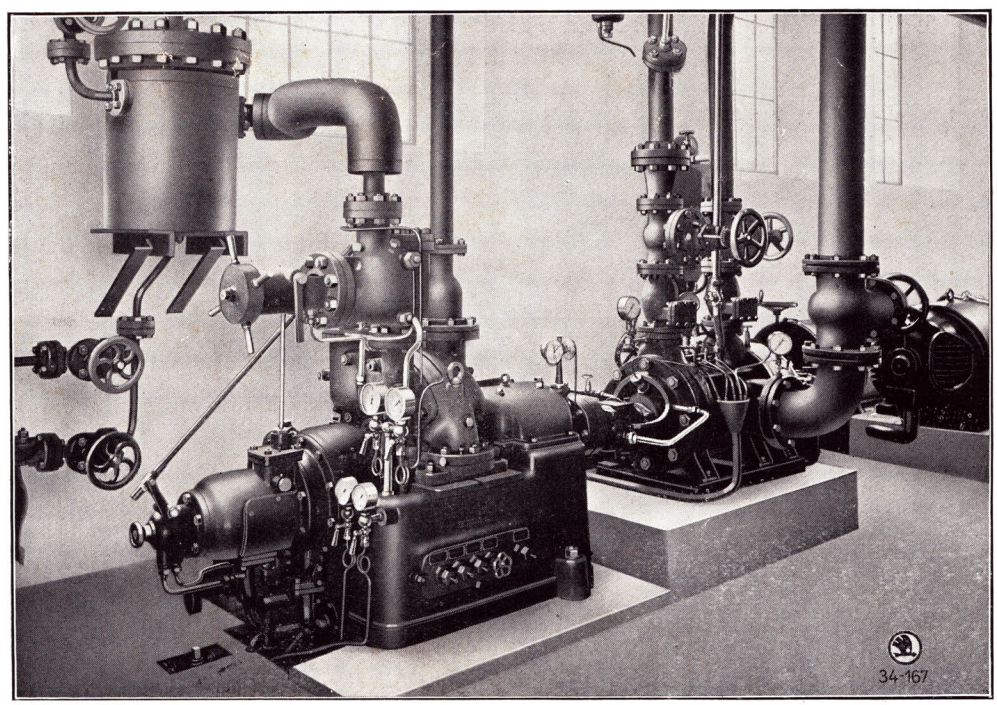


Fig. 87. Turbine-Driven Centrifugal Feed Pump for High Pressure.

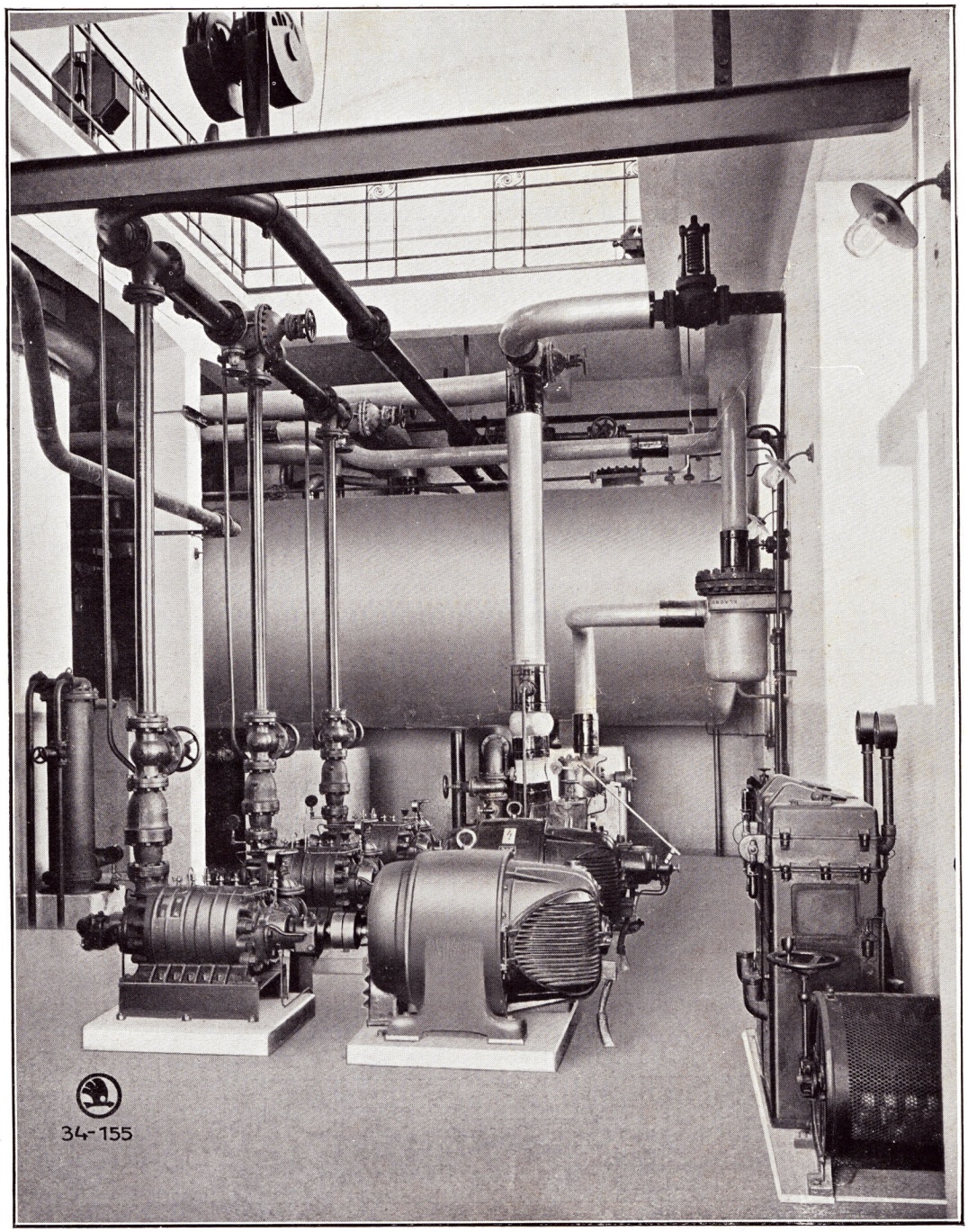


Fig. 88. Electrical and Turbine-Driven Boiler Feed Pumps.

directly connected to the pump and provided with ring lubrication. In the same way as for steam feed pumps the back-pressure steam (exhaust steam) of these driving turbines serves to preheat the feed water.

TREATMENT OF FEED WATER. (PREHEATING, DEAERATION, ETC.)

Suitable preliminary treatment of the feed water is the most important condition for regular and economical boiler work. The methods used for this treatment depend on the size of the boiler, the steam pressure, and the specific boiler rating.

In a short time the equipment will pay for itself by saving fuel, by the permanent high degree of efficiency of the boiler, as well as by savings in boiler cleaning and repairs, and increased safety in working. Finally a faultless treatment of feed water permits an increased specific rating of the boiler, whereby considerable savings in capital investment can frequently by made.

The preliminary treatment of feed water consists in eliminating impurities, salts (hardness), and gases from the water, and thus avoiding sediments of mud or scale, and at the same time corrosion of the boiler equipment.

The impurities are removed by filtration, the dissolved salts either by heating in the case of temporary hardness, or by chemical softening, or by evaporation in the case of permanent hardness. The air is eliminated by heating the feed water and flashing it in properly vented deaerators.

Heating the water is advantageous also for the chemical softening process, as the reaction is accelerated. For this operation it is usual to utilize the exhaust steam from evaporators, steam driven feed pumps and other steam engines, injectors, etc.

Heating by means of bled steam from turbines or steam engines has a favourable influence on the heat efficiency of the whole heat cycle (regenerative heat cycle). Finally fluctuations in steam consumption can be equalized by regulating the quantity of steam for heating up the feed water and by collecting the preheated water.

Samples of water are required to enable us to offer the most suitable feed-water treatment. These samples are analysed in the special, well-equipped laboratory of our research institute in Plzeň (Fig. 19).

It is advantageous to combine all these functions in a suitable way so that the best results can be obtained with as simple an equipment as possible, the heat losses limited, and the efficiency of the whole heat circulation increased.

A large number of combinations are possible, their choice depending on various circumstances, such as the chemical composition of the water, the quantity of condensate, the size of the plant, its purpose, etc.

We construct water preheaters either as open heaters (often combined with a deaerating equipment) or as surface feed heaters with a nest of brass tubes.

For purifying water chemically we frequently employ the hot lime and soda process, which is simple and reliable. This chemical cleaning apparatus consists of a soda feed mechanism, a soda tank, a lime saturator, a reaction tank, and a filter for separating impurities.

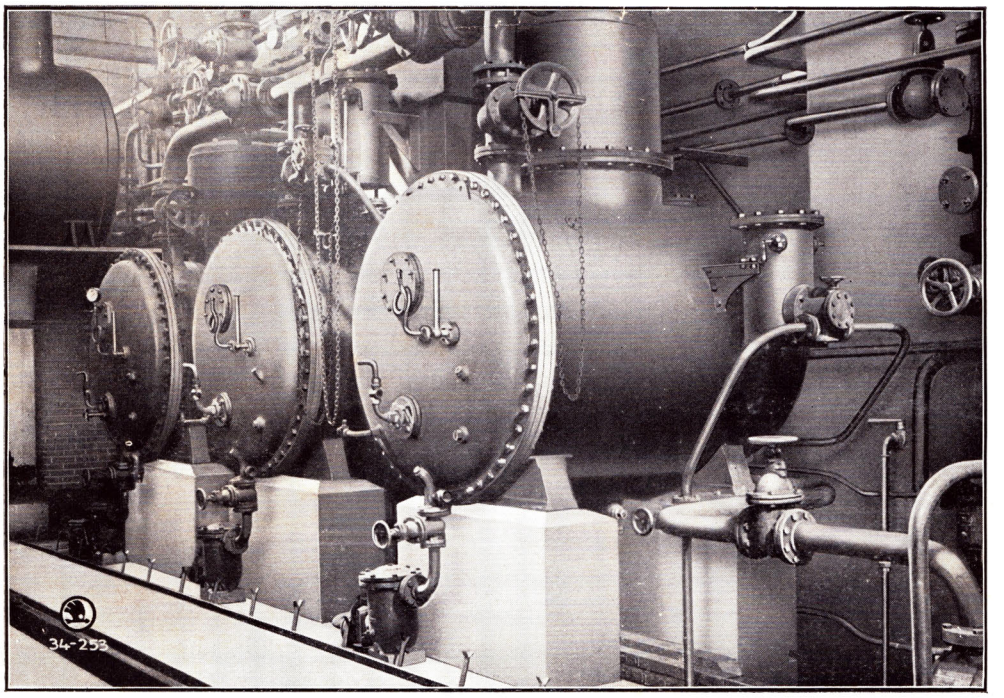


Fig. 89. Triple-Effect Evaporator in Course of Erection (not yet insulated).

According to the quantity of distillate required and the working conditions, we construct evaporator plants either single or multi-effect. The individual stages consist of horizontal or vertical evaporation cells with immerged heating coils, which can easily be taken out for cleaning purposes. The vapours from the last stage serve to heat and deaerate the untreated water and the return turbine condensate, or they are partly raised to a high pressure by steam compressors (thermo compressors) so as to be able to work again in the higher stages. Frequently such evaporation stations are combined with pretreatment of the water in chemical purifiers.

For all this equipment we manufacture the necessary centrifugal pumps, tanks, fittings, and connecting piping.

COAL AND ASH-HANDLING EQUIPMENT.

The conveying equipment for coal supply and ash removal forms a further important auxiliary device in boiler houses. Our special department for the construction of cranes and transport equipment has designed suitable and approved equipment for boiler plants of all sizes and working conditions. The following illustrations (see Figs. 90 to 102) show some of this equipment.

The construction of conveying equipment depends entirely on local circumstances and the output required. In the case of small plants the trucks are usually unloaded by hand into chutes or bunkers arranged along the track. In larger plants they are unloaded by grabs, crabs, grab cranes, or pneumatically. In very large plants waggon dumping devices are used.

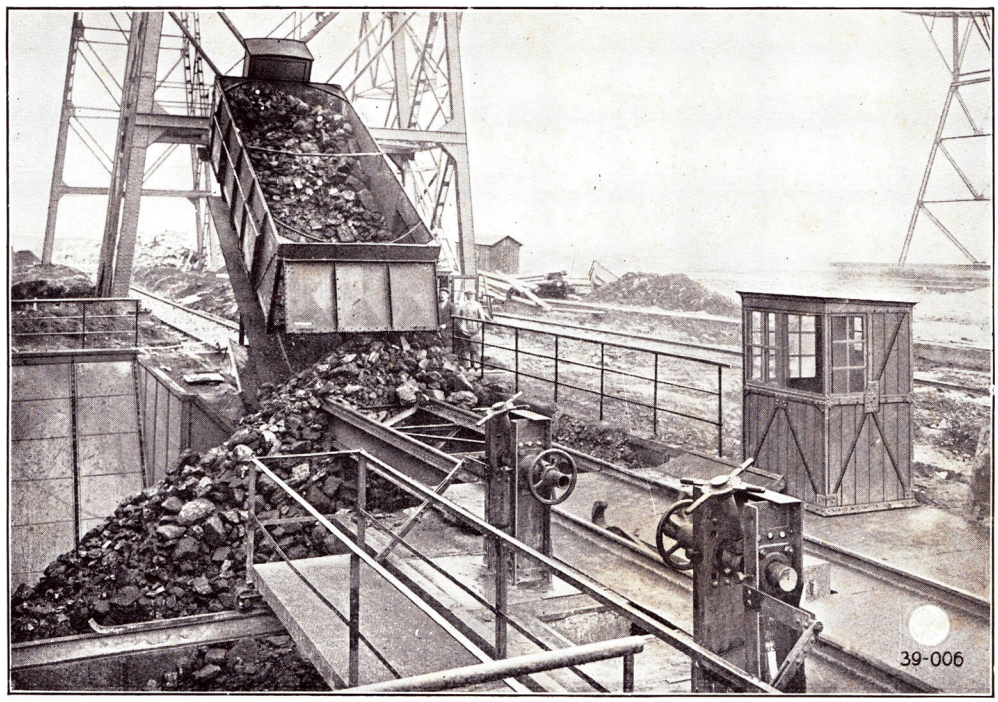


Fig. 90. Waggon Tipping Device in Operation.

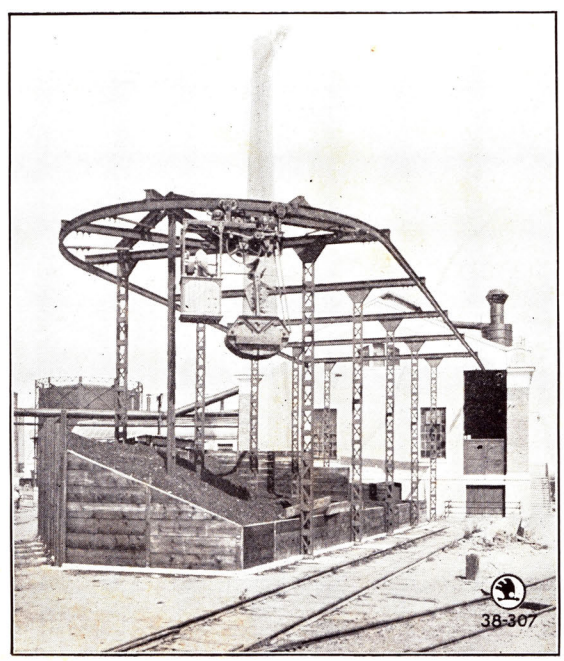


Fig. 91. Electric Suspended Railway with Crab for Small Outputs.

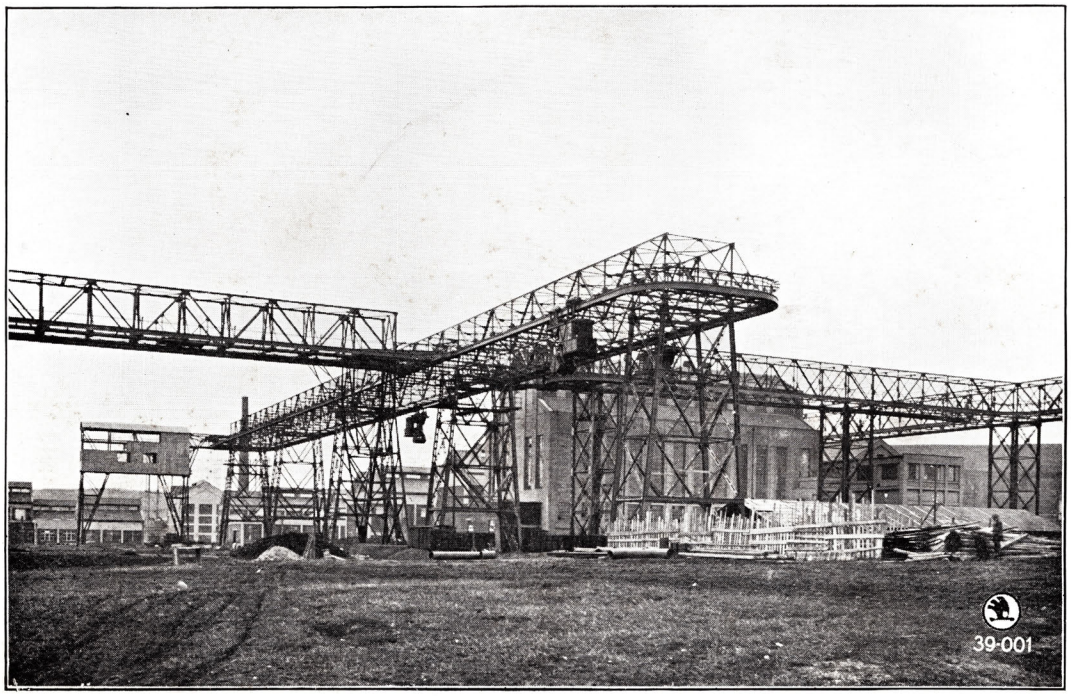


Fig. 92. Electric Suspended Railway with Crab for Large Outputs.

Fig. 93. Gantry Crane with Crab.